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THE SCIENTIFIC WORK OF THE SECOND BYRD ANTARCTIC EXPEDITION

By Dr THOS C. POULTER

SECOND IN COMMAND OF EXPEDITION, DIRECTOR OF RESEARCH FOUNDATION, ARMOUR INSTITUTE OF TECHNOLOGY

THE second Byrd Antarctic Expedition embarked from Boston on October 11, 1933 After passing through the Panama Canal, we touched Easter Island, then crossed the Pacific to Wellington, New Zealand A southeast course from there brought our vessel into ice-filled Antarctic waters east of the Ross Sea A large area of unknown ocean was explored by ship and airplane as far east as the 116th meridian, where we turned westward again One month after the ship had first entered the pack-ice, it reached the southernmost shore of the Ross Sea The Bay of Whales is that point on the circumference of the Antarctic continent where the ocean encroaches farthest toward the pole Here at 78° 34′ S and 163° 56′ W, the base camp was established on the floating shelf ice of the Ross Barrier The ice-party occupied the Bay of Whales base from January 17, 1934, until February 5, 1935, while the ships wintered in New Zealand The itinerary of the return voyage included Dunedin, New Zealand, Easter Island, Albemarle Island, of the Galapagos archipelago, and Panama The expedition arrived in the United States on May 10, 1935, after an absence of nineteen months

More than two years had been spent in making very elaborate preparations for a comprehensive scientific program It is gratifying to find in summarizing the accomplishments of the expedition that a great deal of the original program has been carried out This paper briefly summarizes the scientific accomplishments of the expedition The complete report will occupy the equivalent of about ten volumes of three hundred pages each

OCEANOGRAPHY

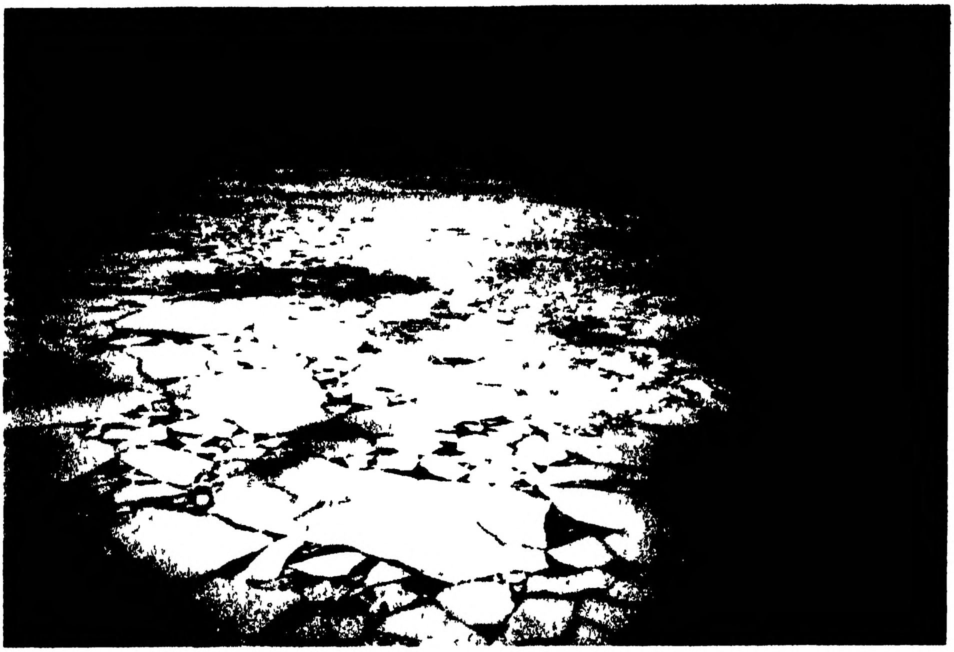
The oceanographic program of the expedition included a systematic bathymetric survey in the form of echo soundings taken hourly, *i e*, about seven miles apart except when an outstanding change in bottom configuration was encountered or when the continental insular shelf was approached and left On these occasions the number of soundings was increased to whatever number was required to obtain a detailed profile of the bottom In all, ten series totalling 2,723 soundings were made from the *Bear of Oakland* during its two trips to and from the Antarctic and on cruises while there

COSMIC RAYS

In order to extend the cosmic-ray measurements of the world-wide survey made by Dr A H Compton, of the University of Chicago, into the south Pacific and the Antarctic, a large number of cosmic-ray measurements were made on our southern voyage and during our stay at Little America

ICE STUDIES

A very extensive study was made of the ice conditions from the time we sighted



AERIAL VIEW OF THE ICE PACK, APPROACHING THE ANTARCTIC
THE LARGER PIECES ARE ABOUT A MILE IN DIAMETER AND A HUNDRED FEET THICK.

our first ice and continued throughout our stay in the Antarctic

Aerial photographs of the pack-ice and icebergs supplement the pictures and records made from the two ships The largest individual bergs covered an area of two hundred square miles Studies were made of the stratification, porosity, general structure and movement of the continental and shelf ice

That vast extent of about 100,000 square miles of shelf ice between the Ross Sea and the Queen Maud Mountains was found to average more than a thousand feet in thickness, and that portion of it forming the west edge of the Bay of Whales was found to be moving northward and a little to the east at an average rate of eight feet per day, and the ice on which Little America was built was moving westward at the rate of two feet per day

The frequent boom of snow tremors, allowing the snow underfoot to drop suddenly sometimes more than an inch, kept the surface traveler constantly reminded of that great dread of the Antarctic, the so-called blind crevasses

Ornithology

Fifty-four species of birds were identified in the course of the second expedition Twenty-three of these were non-oceanic birds which came aboard ship from October 14 to 30 between New York and Panama Nine species of sparrows and four species of warblers were among the passerine birds.

The ornithological collection of the expedition consists of one hundred and seventeen skins, chiefly of the larger oceanic birds Twenty species are included, representing ten families

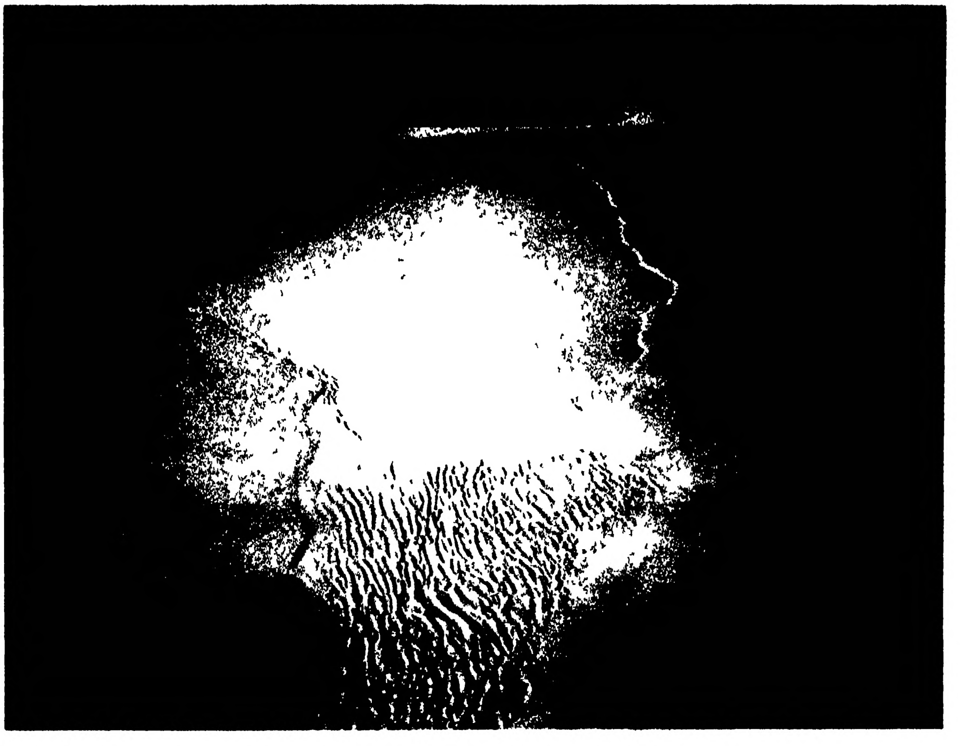
The Antarctic pack is a purgatory for the navigator, but a paradise for the observer of bird and mammal life Unfortunately for the latter, no pack-ice was encountered on our return voyage How-

ever, this brought a measure of compensation in its effect on the southward occurrence of albatrosses, so that the known non-breeding ranges of three species were extended The most southerly range of light-mantled sooty albatross, the black-browed albatross, the stately wandering albatross was extended 230, 210 and 100 geographical miles, respectively, for the three species. In the "roaring forties" two male wandering albatrosses were collected, the larger weighing nineteen pounds and measuring ten feet and nine inches in extent

The snow petrel is the most abundant bird in the pack-ice It lives largely on the shrimp-like reddish crustacean which is also the principal food of the Adelie penguin, the crab-eater seal and other denizens of the Antarctic pack The snow petrel's plumage is white, with ivory tones, its beak, eyes, tarsi and feet are black This would be an altogether attractive bird were it not for its accuracy and eight-foot range in ejecting the oily, orange-colored contents of its stomach at the intruder

The sun reappears at the Bay of Whales on August 22 The earliest spring migrants are the snow and Antarctic petrels A lone snow petrel and two Antarctic petrels arrived on October 6, but they did not become common on the bay until December, or midsummer The last snow petrel seen in the autumn was on March 13, after which no birds of any kind were observed

No birds breed in the Bay of Whales



AIRPLANE VIEW OF THE BAY OF WHALES

IN EARLY SUMMER BEFORE THE ICE HAD GONE OUT—TAKEN FROM ELEVATION OF ABOUT 15,000 FEET. THE PORTION CLEARED OF ICE THE PRECEDING SUMMER IS SHOWN IN THE UPPER CENTER; THE PORTION NOT CLEARED, IN THE LOWER CENTER LITTLE AMERICA IS TO THE RIGHT OF WHERE THE NEW ICE JOINS THE OLD

GENERAL VIEW OF LITTLE AMERICA BEFORE IT HAD BEEN COMPLETELY DRIFTED OVER WITH SNOW

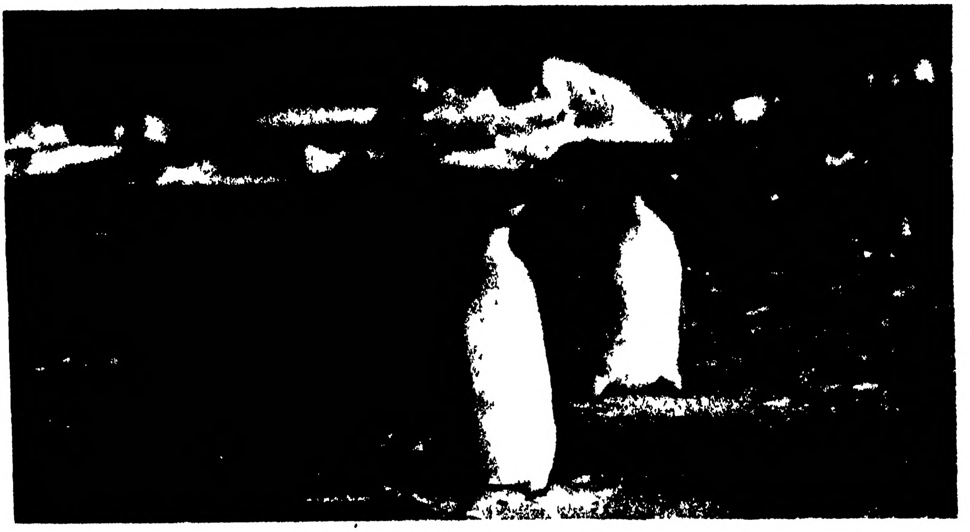
region The only known breeding ground within four hundred miles is a rookery of snow petrels discovered by a four-man sledging party which Siple led into the mountain ranges of Marie Byrd Land

On the lower slopes of Mount Helen Washington on December 19, 1934, the rookery was located, where snow petrels were sitting on their eggs deep in the crevices among the rocks They defended their nests with the customary marksmanship No nests of the Antarctic petrel were found, but from the numbers of the birds it seems likely that they nest on this peak with the snow petrels A fact of unusual interest is the distance of this nesting site from the nearest water The birds nest fifty-one statute miles from their nearest possible source of food This disadvantage seems to be counterbalanced by the nature of the peak, where many sheltered nesting sites are available among the loosely aggregated rocks Winds of hurricane force sweep over the peak to prevent large accumulations of snow, while the dark rock contributes by absorbing the sun's heat and melting the snow Finding this rookery extends the breeding range of the snow petrel 452 statute miles to the south

In the ice-pack in January, flocks of hundreds of Antarctic petrels were seen wheeling in unison above the great tabular bergs About seventeen inches in length, or three inches longer than the snow petrel, this bird is no less beautiful Its chocolate-brown head, back and wings furnish a pleasing contrast with the whiteness of the wing coverts and other parts

The silver-gray petrel is the least common of the birds known to visit the Bay of Whales. Our only specimen collected was secured on the Antarctic Circle and the 150th meridian, at the northern edge of the pack

The Cape pigeon has never been reported in the Bay of Whales The Wilson's storm petrel breeds only on Antarctic and sub-Antarctic islands and on



EMPEROR PENGUINS

shores of the Antarctic continent This species migrates as far north as Labrador during the southern winter As for all birds which reach the Bay of Whales, except the South Polar skua, this station marks its southernmost limit We never saw them alight on the ice

The giant fulmar, or giant petrel, appeared at Discovery Inlet, but not one had been reported at the Bay of Whales until the autumn of 1933 This species has two color phases, a brown and a white, with intermediate conditions In cruising along the barrier cliff between

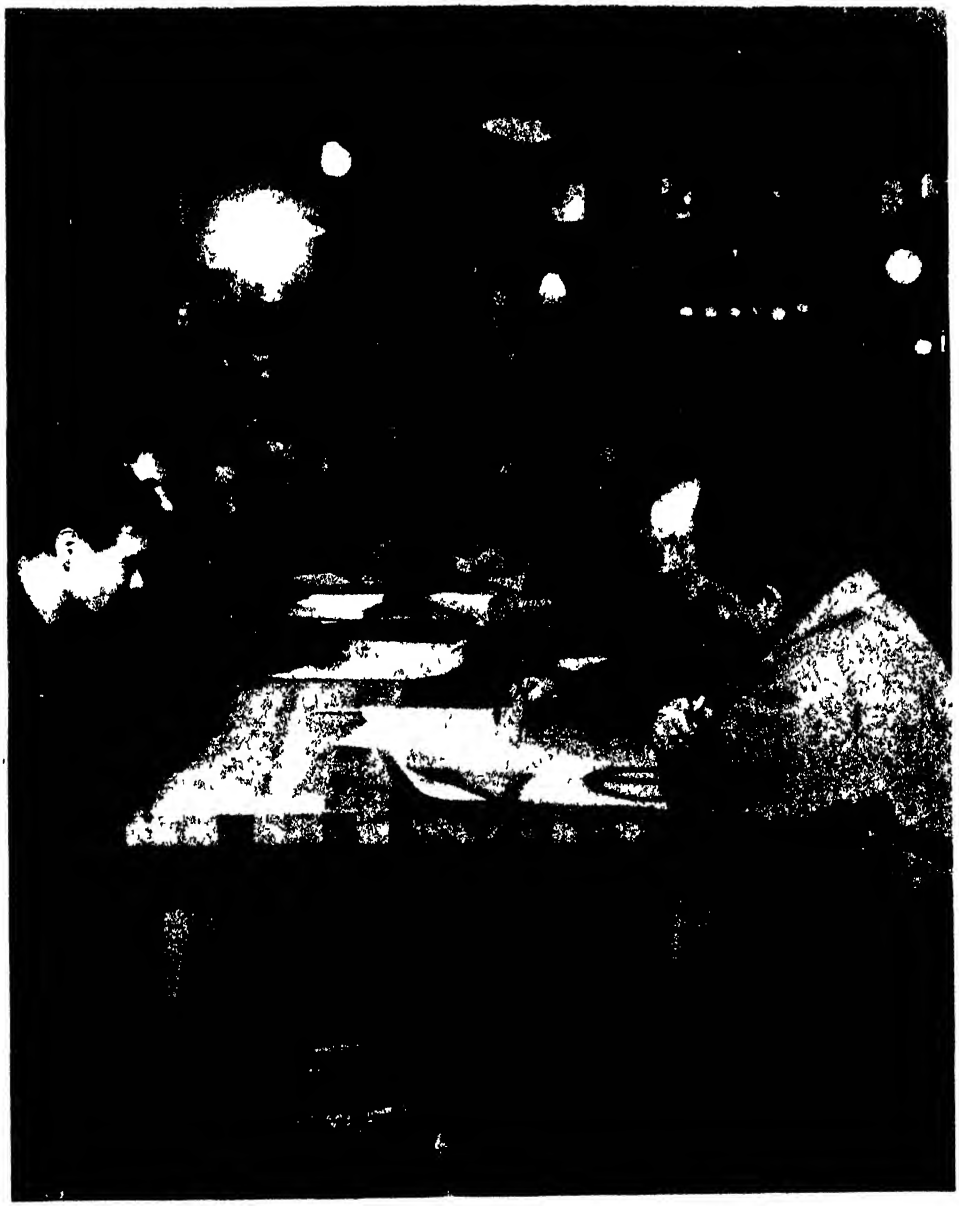
PRESSURE ICE IN THE VICINITY OF LITTLE AMERICA.

the Bay of Whales and Discovery Inlet, we saw a flock of about fifty which had settled on an ice floe Within the scope of our observations the white birds constituted only 3.3 per cent of the sixty individuals, as compared with Wilson's 23 per cent

The drama of Antarctic bird life is not without its villain Theft and pillage, murder, cannibalism and infanticide, these crimes are all in the repertory of the South Polar skua The Adelie penguins are immune to this plague only because they nest in the middle of winter, sharing with no other bird species the rigor of the polar night At the aforementioned snow petrel rookery there were skuas about Doubtless the petrels' habit of laying their eggs in narrow crannies serves to protect the eggs and young from skuas, as well as from the force of frequent blizzards The South Polar skua wanders farther south over the continent than any other bird The southern geological party reported an observation made by this party at 86° 05′ S, thirty miles up the Thorne Glacier, at an altitude over two thousand feet The birds settled on the snow near the dog lines, rested for a time and finally took off, flying north, continuing the flight down the glacier. These facts suggest that the skuas may have been on a flight across the Antarctic continent

The emperor penguins, the largest of living penguins, were more frequent visitors to the Bay of Whales than the Adelies in 1934–35, but the reverse was true in 1929–30 Their remarkable habit of breeding during the extreme cold and darkness of the Antarctic night leaves them free in summer to wander along the coast and through the ice-pack Many emperors are to be seen in the pack during December and January, both juvenile and black-throated birds Others of both groups seek coastal bay ice, such as the Bay of Whales affords, on which to moult Although conspicuous by virtue of their size, coloration and loud reedy, whining call-note, emperors are by no means abundant in the bay Through-

THE BIOLOGICAL STAFF AT WORK IN THE SCIENCE LABORATORY
EXAMINING BACTERIA, PLANKTON, MOSSES AND ALGAE COLLECTED IN ANTARCTICA.



SCIENTIFIC STAFF MEETING IN THE SCIENCE LABORATORY
DR. POULTER IS AT THE HEAD OF THE TABLE

out the summer of 1934–35, though we were on the bay almost daily for three months, the total number of emperors seen was only thirty-two The first in the spring appeared on November 5, after which none was seen for a month Eighteen specimens taken in November and December, before the moult, ranged from 60 to 84 pounds, while eleven taken after the moult in February ranged from 39 to

DR PERKINS MAKING MOVING PICTURE RECORDS OF LIVING PLANKTON SPECIMENS

55 pounds Motion picture and sound records were made of the emperor and Adelie penguins

After an unsuccessful attempt on the first Byrd expedition to bring back living Antarctic penguins for American zoos, another attempt was made on the second trip. The captives were kept at the base camp, where an area of about 5,000 square feet of snow was enclosed by a wire netting The first birds caught were kept there for two months before being transferred to the ship Frozen fish had been purchased in New Zealand for feeding them

On leaving the Antarctic we had twenty-one captive Adelies and nineteen emperors housed amidships in an air-conditioned, refrigerated, cork-insulated room forty feet long, six feet wide and seven feet high After three weeks at sea, when the birds had been kept for two or three months in captivity, most of the emperors no longer required forcible feeding On the contrary, they had become very tame and friendly, since a new association had finally been formed and man now symbolized food The young emperors were far behind the adults in their conditioning to hand-feeding, and were more vicious in defending themselves against being fed The Adelies showed still less adaptability and more pugnacity Their stout hooked beaks proved much more formidable weapons than the long, curved bills of the emperors If the powerful emperors had fought as strenuously in proportion to size, keeping them alive would have been quite impossible

Unfortunately for the captives, the return voyage to America took more than three months, due to the slow pace of the ships and an extended stay in New Zealand, where many of the Adelies died By the time the expedition had crossed the tropics, nine of the emperors had died from a heavy mycosis infection of the

lungs, tracheae and air sacs Ten emperors and one Adelie penguin reached the United States alive and were delivered to the Chicago Zoological Society. The last of these died about two months later of the same disease The society transferred these birds to the Field Museum of Natural History, where they are now on display as a habitat group

Plankton and Invertebrates

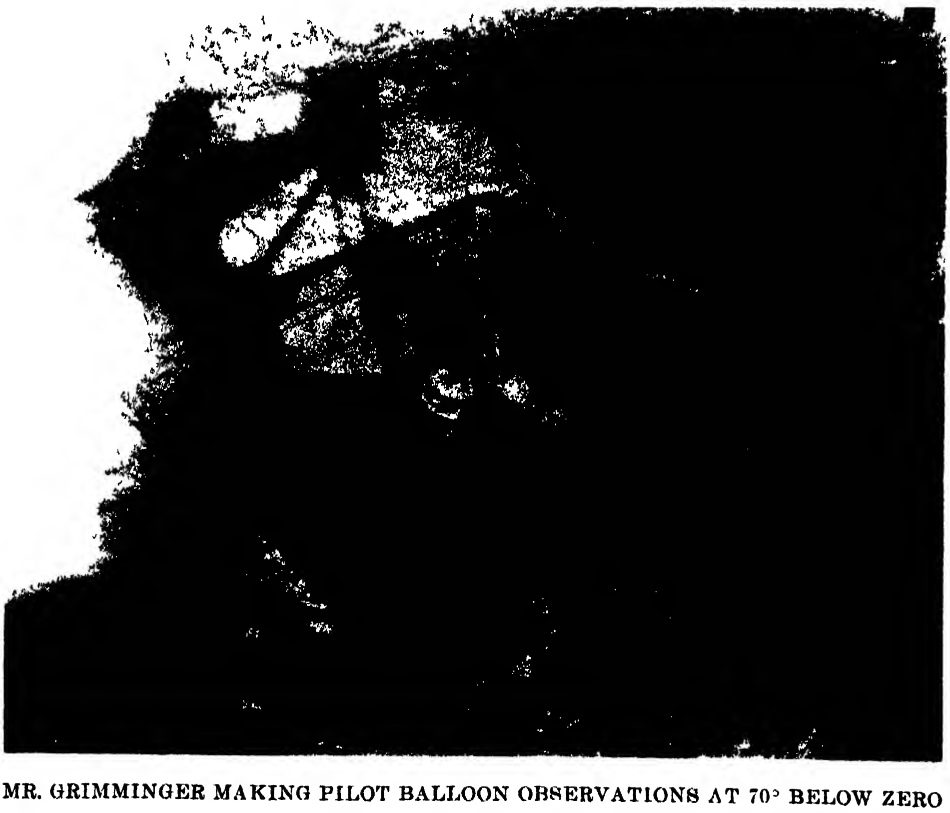
Plankton samples were collected on the various voyages of the two expedition ships, and dredge hauls were made in the Bay of Whales Photomicrographic and cinemicrographic records were made of all materials collected

The bottom fauna included sponges, coelenterates, bryozoans, brachiopods, polychaete and sipunculid worms, pycnogonids, bivalve molluscs, all classes of echinoderms and tunicates

Bacteriology

Aseptically collected samples were collected from the environs of Little America, from many points on the snow surface within 400 miles of Little America, from morainic alluvium, lichens, mosses, exposures of mud and water known to contain algae, rotifers and infusoria, mud from 3,000-feet depth in the Bay of Whales, infections caused from handling seal blubber, abandoned rooms of the B A E I, agar plates, which were exposed on mountain peaks never previously visited by man, and from snow on Thorne Glacier within 180 miles of the South Pole

At Little America, Siple and Sterrett



MR. GRIMMINGER MAKING PILOT BALLOON OBSERVATIONS AT 70° BELOW ZERO

TWO OF FOUR METEOR OBSERVERS SEATED ON A ROTATING PLATFORM
THE MAN SEATED BELOW IS RECORDING THE OBSERVATIONS THE RETICLES THROUGH WHICH THEY LOOK AT THE SKY ARE SHOWN IN THE NEXT PICTURE

had sufficient equipment to make isolations from snow samples, however, cramped quarters and dangers from mold contamination made it advisable to abandon most of the research to laboratories outside the Antarctic Some thirteen isolations were taken from the snow and other sources As to distribution it was found that probably as few as one or two bacteria exist on the average pint of Antarctic surface snow The majority of aseptically taken samples were brought back sealed and opened for the first time in the bacteriology laboratory of Allegheny College, Meadville, Pennsylvania

There are perhaps, at least, 75 different kinds of bacteria In addition to the two yeasts, there are twelve coccus forms, while the remainder are rods and perhaps half of the collection are spore-forming bacilli

Botany

The Marie Byrd Land exploring party, composed of Paul A Siple as biologist, Alton Wade as geologist and S Corey and O Stancliff as assistants and dog drivers, returned to Little America after a three-months intensive sledding journey in December, 1934, with an unusually large collection of mosses, lichens and algae native to the Nunataks of that land This collection was supplemented by the collection made by the Queen Maud Geological Party The collection was packed in a strong box and not disturbed to any extent until turned over to Dr Carrol W Dodge and Mr Edwin Bartram

From the thousands of plant colonies reviewed in the field and hundreds brought back to the laboratory for identification, at least 89 species of lichens and five mosses have been determined The

lichens were collected from some 215 distinct locations and 12 mountains, and on 8 of the 12 mountains there were relatively few mosses This collection no doubt represents the majority of the larger and more conspicuous species, but most of the mountains had species apparently restricted to them Of the mountain exposures where plant life probably exists, less than 10 per cent of the area has been visited

In the light of observations made in Marie Byrd Land, it seems probable that the plant species of Antarctica are much more numerous on the continent proper than the one or two hundred known species thus far collected would indicate

Museum Specimens

A collection of museum skins was obtained for the American Museum of Natural History, including 43 Weddel and crab-eater seal skins with accompanying skulls Additional skulls of both species, making a total of 112 skulls, a large number of embryo seals, chiefly those of the Weddel seal, were also collected

One hundred and twelve oceanic bird skins of about twenty species, including penguins, albatrosses, skua gulls, shearwaters, petrels, frigate-birds, boobies, tropic birds, etc , are included in the collection

Fish of the genus Pleurogramma and a new Antarctic fish "Pagothenia," in addition to two flying fish, reef fish from Easter Island and sea basses and mackerel from the Galapagos Islands constituted a part of the collections

Medical

A study was made of the physical effects of the Antarctic conditions upon the personnel of the expedition Each member was subjected to a physical examination, including a blood count, tak-

RETICLES USED IN DETERMINING PATHS OF METEORS
MOUNTED ON TOP OF A SHACK, WHICH IS BURIED UNDER THE SNOW

OBSERVING METEORS WITH BINOCULARS FROM THE WORKSHOP AND OBSERVATORY

ing of blood pressure and a general physical condition check-up once each month during the winter night. The treatment and effect of frost bite, snow blindness and other conditions peculiar to the Antarctic were studied.

In addition there was an appendectomy performed, a case of streptococcus throat infection, plus other numerous infections and sprains.

Meteorology

The meteorology observations constituted one of the major activities of the expedition. In addition to the two meteorologists making continuous observations of weather conditions at Little America throughout our stay there, pilot balloon observations were made twice daily, and on certain occasions every few hours.

Aerological soundings were made with the autogyro, Pilgrim and Condor planes at frequent intervals from September, 1934, to February, 1935. The three major field parties kept complete records of conditions encountered during the nearly three months they were on the trail.

For the first time in the history of Antarctic exploration, an inland weather station was established, the Bolling Advance Base, occupied for seven months by Admiral Byrd, including the long winter night. The set of weather observations made by Admiral Byrd in spite of the almost impossible conditions under which he was forced to work are surprisingly complete and constitute one of the most valuable chapters in Antarctic weather records.

Temperatures ranged from only a few degrees above freezing to more than 80

degrees below zero, and one period of six weeks averaged more than 60 degrees below zero

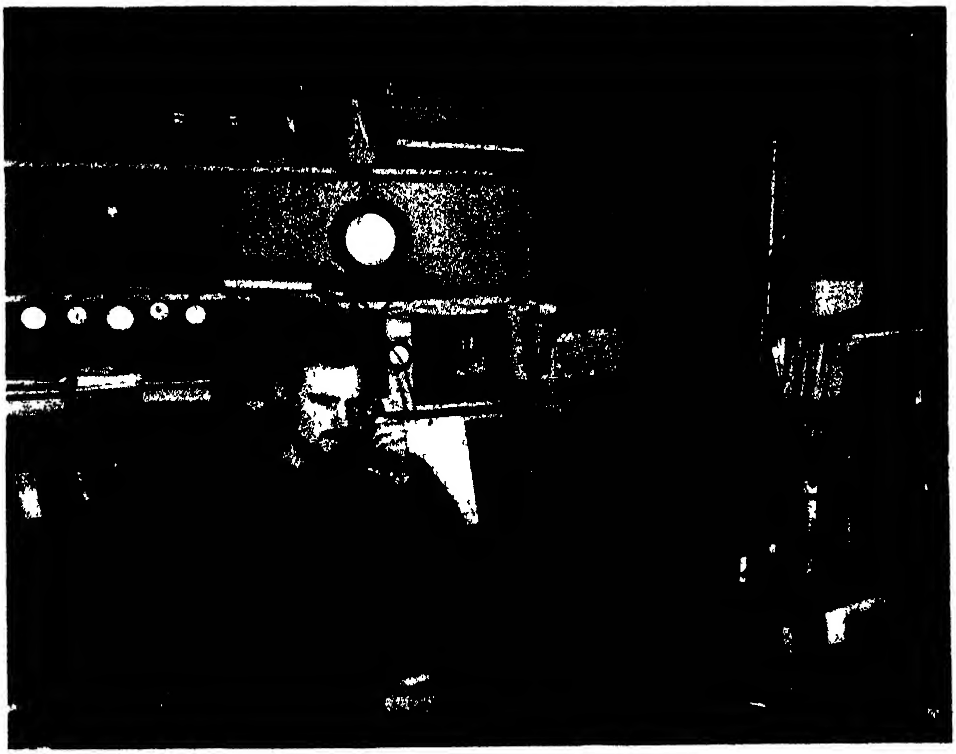
The average wind velocity at Little America of eleven miles per hour is considerably lower than at many places in the Antarctic The maximum velocity on the continent was 60 miles per hour, while higher velocities were encountered at sea

Astronomy

The Aurora Australis is visible at Little America more than half of the time that conditions are favorable for seeing it, and about two hundred and fifty photographs were taken of typical aurora forms and a great many visual records were made

Because of the interference of bad weather, sunlight, moonlight and auroral light, it was only possible to make meteor records over an observing time totalling a little less than seven days However, in this time observations were made on about seven thousand meteors

Two distinct methods of observing were employed, and in both of them most of the observations were made with the observer in a heated shack One method was with the unaided eye and the use of a reticle which served as an arbitrary system of coordinates For these observations from one to four observers were seated on a rotating platform in such a way that the observer's eye came directly behind an opening in the small dome of the roof of the shack The four reticles were mounted in the roof of the shack so that the center of the field covered by each of the four observers was at an elevation



TELEPHONING FROM THE SCIENCE LABORATORY

DR BRAMHALL, PHYSICIST, COMMUNICATING WITH AN ASSISTANT IN THE MAGNETIC OBSERVATORY.

of about 45 degrees, and the four reticles pointed in each of the four directions The platform was rotated a quarter of a revolution once every fifteen minutes so that in a regular two-hour period each of the observers had observed twice in each of the four positions. Nearly two thousand meteors were observed by this method, and the coordinates of both ends of the path recorded, together with the time to the nearest second, magnitude, color and duration of train, if one.

One observer observing through an eyepiece and reticle mounted in the roof of the shack permitted observations to be made in the Zenith About one thousand meteors were observed through this reticle, and the complete data recorded for each meteor

The other method involved the use of 7 x 50 Zeiss U S Navy Binoculars They were mounted in the ceiling of the shack and directed at the Zenith They covered a field of about seven degrees, and about 1,300 meteors were observed by this method The same data were recorded for these as in the case where the reticle was used The number that it was possible to record by this method depended upon the speed with which the observer could call off the positions and the recorder could take them down, as they were appearing much faster than it was possible to record data

Because of the rate at which meteors could be observed with binoculars when the visibility was very good, it was decided to record only one number for each meteor and that representing the direction that it was traveling. In this way observations were made on about 1,500 meteors, and the rate at which they were recorded varied from 6 to 35 per minute

A reticle was taken to Advance Base during the latter part of the winter night, and a series of simultaneous observations were made with two observers watching the same section of the sky for the determination of real heights This gave a base line of about 100 miles While the

BROADCASTING CONTROL ROOM AT LITTLE AMERICA

GEOPHYSICS PARTY ON THE TRAIL
MAKING A SURVEY OF THE BAY OF WHALES REGION NOTE THE SEALS ASLEEP ON THE ICE IN THE BACKGROUND

number of actual duplicates observed was rather small, several hundred meteors were recorded during these observations

Data were recorded on all fireballs observed by any of the members of the expedition Five meteors left trains lasting long enough for the drift to be measured, thereby making it possible to determine the direction and approximate velocity of the wind at an elevation of between 50 and 100 miles above the surface of the earth In all five cases, the drift was from west to east at a rate of about 150 miles per hour

Insofar as was possible the observations were distributed through the twenty-four hours so as to obtain, if possible, the diurnal variation in the numbers of meteors striking the earth's surface

Observations were also made on the magnitude of the two variable stars, Beta Doradus and Carinae, at frequent intervals throughout the winter night A large number of star sights were also made through the winter night for accurately determining the position of Little America and Advance Base Many of these were made at a temperature of more than 70 degrees below zero

Terrestrial Magnetism

With the aid of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, the expedition was completely equipped with continuous recording magnetic instruments as well as instruments for making absolute measurements of Little America and on the trail In addition to the many field observations in the Antarctic, measurements were made at Easter Island, Albemarle Island, Panama Canal Zone and New Zealand

Geophysics

The mystery of what lay hidden beneath the snow surface in the Antarctic led us to include in our scientific equipment an instrument new in polar exploration and research This was a geophysics seismograph with which we were able to measure the thickness of the ice, tell whether it was resting on rock or floating on water, and if floating on water

how thick the water layer was and something about the stratification of the bottom With this equipment we made more than 500 soundings at 135 stations

These measurements explained many of the mysteries of the Ross Shelf Ice, such as crevassed areas, the existence of the Bay of Whales, Discovery Inlet, Lindbergh Inlet, as well as proved the existence of Roosevelt Land.

We traveled 2,000 miles on skis with this equipment and an equal distance by plane, measuring continental ice thicknesses of more than 2,000 feet and floating ice of 1,500 feet

Geology

The geological program of the expedition was one in which there was a great deal of activity Fourteen mountains in the Edsel Ford range were visited by the Marie Byrd Land party The range was found to be composed of greatly folded and higher metamorphosed sediments which have been uplifted and intruded by massive and granodiorites The structure of these mountains was observed and the effects of the Antarctic agents of weathering on the rocks was studied An extinct volcanic cone composed of an olivene basalt was discovered and visited The party stopped at Mount Helen Washington in the Rockefeller Mountains on the homeward journey to collect specimens for correlation of this range with the Edsel Ford Range

Rocks and pebbles collected from an iceberg at sea, and those taken from the stomachs of seals and penguins, together with those obtained in dredgings from the bottom of the Bay of Whales have been studied to see where they fit into the geologic picture of the Antarctic

Another major geologic endeavor of the expedition was that of the Queen Maud Range party. Blackburn, leader of the party, was assisted by Paine and Russell in the trip across the Ross Shelf Ice to the Queen Maud Mountains and ascent of the Thorne Glacier They painstakingly collected specimens and recorded data for the construction of a cross-section of this range, paying particular attention to the sedimentary beds near the top on which many fossils, leaves, branches and even tree trunks were found Twenty different seams of coal were found exposed along the side of the glacier

Radio

During the weekly broadcasts and daily communications with the United States and Expedition ships, the radio engineers made frequent records of transmission and reception conditions, the interference accompanying displays, magnetic disturbances and audio static

Space here does not permit adequate acknowledgment of our sincere appreciation of the valuable assistance and cooperation that we have received from the large number of scientists and scientific organizations

FOREST PYROLOGY

By H. T. GISBORNE

SENIOR SILVICULTURIST, NORTHERN ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

AMERICAN forestry inherited from European practices no science or technology of fire control. No formalistic theories nor established foundations of knowledge were available for fire such as were inherited for silviculture, wood technology, forest pathology and forest entomology. There was no science of forest pyrology.

It was not until 1916, in fact, that a specific proposal was formally made to apply research methods to fire as a forest phenomenon, and not until 1926 that the research possibilities were stated in detail. In both cases, Dr. Earle H. Clapp, associate chief, U. S. Forest Service, was the author, and his second proposal, contained in "A National Program of Forest Research," published in 1926 by the American Tree Association, has been and still is the master working plan for the guidance of forest fire research in evolving a science of forest pyrology.

This national program distinguished six components of the fire problem: (1) The laws governing the combustion of forest fuels in the open, (2) fire prevention techniques, (3) fire suppression, including the generalship and tactics, the tools and instruments of this craft, (4) the accurate determination of all forms of damage due to fire, (5) the beneficial uses of fire, (6) the protection standards or objectives which fire control should attempt to attain.

(1) LAWS OF COMBUSTION

Classification has been called "the very essence of scientific method" and a classification of the fuels that burn in forest fires was one feature of the laws of combustion specifically identified by the national program. The need for classifying the many diverse types of fuels which are the *sine qua non* of forest fires is obvious when one remembers that on an average bad fire day the combustion process progresses at only a few square feet per hour in some fuel types, whereas in others the area burned has been as great as 1,000 *acres* or more per hour. As W. I. Wyman has stated:

> To bring like things together to form distinct groups and to separate groups according to their distinguishing properties are measures that consciously or unconsciously have been adopted by humanity from time immemorial. This cerebral process is a method of classification and is not only the basis of any scientific system but is an active principle in all systematic procedure. All ordered thought is based upon it, all ordered performances require it. Dictionaries, directories, correspondence files and trade catalogues are instances of modern requirements in domestic and business life.

In the business of forest fire control research has applied this principle to replace the personal memory and estimate bases formerly employed to determine how many fire control men are needed and where they should be located. The "ordered performance" of fire control obviously will progress faster by systematic rather than subconscious identification and grouping of these basic factors of fuel type.

Show and Kotok pioneered in this attack on fuel type classification evolving a silvical basis for the California forests. Hornby, of the Northern Rocky Mountain Forest and Range Experiment Station, refined this by originating a pyrological basis with definitions of those generic characteristics indicative of (a) rate of spread of fire and (b) resistance to control. Tested by application on

A FOREST FIRE DANGER RESEARCH STATION IN THE "HIGH COUNTRY"

ELEVATION 5,500 FEET, ON THE PRIEST RIVER EXPERIMENTAL FOREST TEMPERATURE, HUMIDITY, WIND VELOCITY, DUFF MOISTURE AND SMALL STICK MOISTURE ARE RECORDED AUTOMATICALLY PRECIPITATION IS MEASURED BY GAGES

17,000,000 acres of national forest, this classification has demonstrated both its scientific soundness and its practical value. More recently, Matthews, of the Pacific Northwest Station, and Curry and Fons, of the California Station, have further advanced the methods of enumeration and quantitative estimate of the elements, in California to the stage of formulation for one fuel type of a rate of spread hypothesis in mathematical form, soon to be published

The National Program definitely recognized the function of fuel moisture as a major control in the combustion process. The problem here was decidedly similar to that existing and later described by Livingston for physiological plant ecology when he stated in 1935 that much must still be done "before we shall be able to devise instruments and techniques by means of which numerical indices of environmental capacity may be secured " "Just what to measure must depend, to a considerable extent and for a long time to come, on what we are able to measure "

Instrumentation, so important to the physiological ecologist, constituted a major impediment to the early progress of forest pyrology The low-cost rain gage, designed by Osborne and improved by McArdle, the low-cost wind gages of the Northern Rocky Mountain and the Pacific Northwest Stations, the fan psychrometer, duff hygrometer, wood cylinders, visibility meters and the anemohygrograph not yet described in any publication have, however, partially or wholly removed some of these impediments Savings of some $6,500 in the cost of rain gages, and $17,000 in the cost of anemometers, with resultant possibilities of more wide-spread measurement, have already been made as a result of this instrumental research, while the invention of duff hygrometers and wood cylinders made possible the measurement of highly significant danger factors which formerly had to be crudely estimated

Research at several experiment stations soon found that except for wind the meteorological elements of insolation, temperature, humidity and precipitation are largely factors of environmental capacity which influence fire behavior only as they affect fuel moisture They are, therefore, indirect indices at best The correlations by Mitchell for the Lake States, Stickel for the Adirondacks and Jemison for the northern Rocky Mountain region have been valuable, however, both in classifying fire danger on the basis of meteorological records alone, in the absence of fuel moisture data, and for evaluating the controls of fuel moisture, or the cause and effect relationships.

The scientifically essential equilibrium relations between temperature, humidity and fuel moisture were first derived by Dunlap, of the U S Forest Products Laboratory, for coniferous fuels in 1924 and for hardwood forest leaves in 1931 Hawley, of the same laboratory, contributed basic information concerning the laws of combustion by his summarization of certain physico-chemical relations applicable to free-burning forest fuels

The effect of fuel moisture on the ease of ignition and inflammability of the duff and litter comprising the forest floor under coniferous stands was early determined in terms of common sources of ignition by Gisborne and Stickel The inflammability of dead branchwood, of green, curing and cured shrubs, grasses and weeds, and of combinations of fuels, the effect of slope and size of fire on rate of spread and many other factors of combustion, however, still remain to be determined As yet, only at the California and Northern Rocky Mountain Stations have certain phases of these problems been brought into the laboratory for controlled examination by physicists and chemists

(2) Fire Prevention

The classification of fuels on a pyro-

THE PRIEST RIVER FIELD LABORATORY
OF THE NORTHERN ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION, LOCATED ON THE KANIKSU NATIONAL FOREST IN NORTHERN IDAHO

logical basis, by Hornby, and the determination of effect of forest canopy density on the inflammability of some of these fuels, by Jemison, have already given the forest executive sound principles of immunization for his guidance in the reduction of inflammable material along rights-of-way, around campgrounds and on all areas exceptionally exposed to the causative agencies A much more efficient railroad engine spark arrester of the cyclone type, invented by a railroad master mechanic but not well accepted until proven by research-conducted tests at the Northern Rocky Mountain Station, has materially affected the prevention of railroad fires, with great benefits both to the railroads and to all forest protective agencies in the northern Rocky Mountain region On one national forest alone, use of this arrester by the transcontinental railroad crossing this forest has reduced the number of railroad fires from an average of one fire per two trains in 1931 to about one fire per eight trains in 1936 and 1937

Immunization by closure of forest areas, by smoking and camping regulations and public warnings has for several years in the northern Rocky Mountain region of the Forest Service been practiced by using the fire danger measurements evolved by the Northern Rocky Mountain Forest and Range Experiment Station as the basis for this form of prevention The prediction of dangerous fire weather, recognized by the National Program as one aid to fire prevention, has been untouched by the forest experiment stations on the premise that such forecasts are preeminently the field of the U. S Weather Bureau.

Lightning, the single unpreventable cause of forest fires, has been studied by

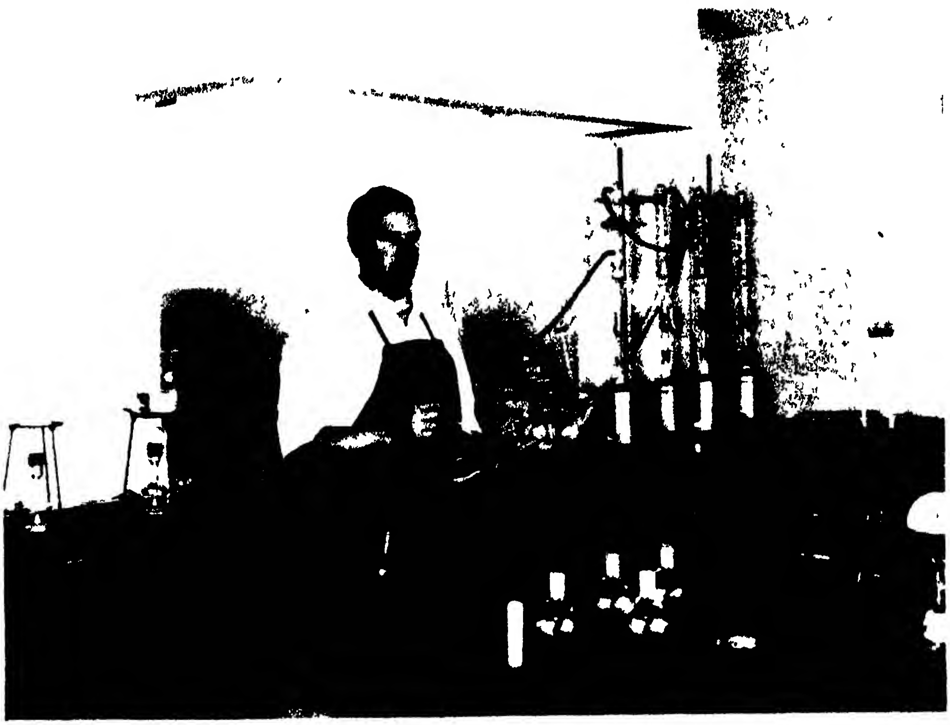
the Weather Bureau and the Forest Experiment Stations in regions of high lightning danger, with resultant increased accuracy of forecasts as well as identification of dangerous versus safe characteristics of storms

Forest fire insurance, an economic phase dependent upon local conditions of combustibility and the activity of the causative agencies, has been thoroughly investigated by Shepard, of the Pacific Northwest Experiment Station, with the finding that insurance rates need not be prohibitive in that region.

(3) Fire Suppression

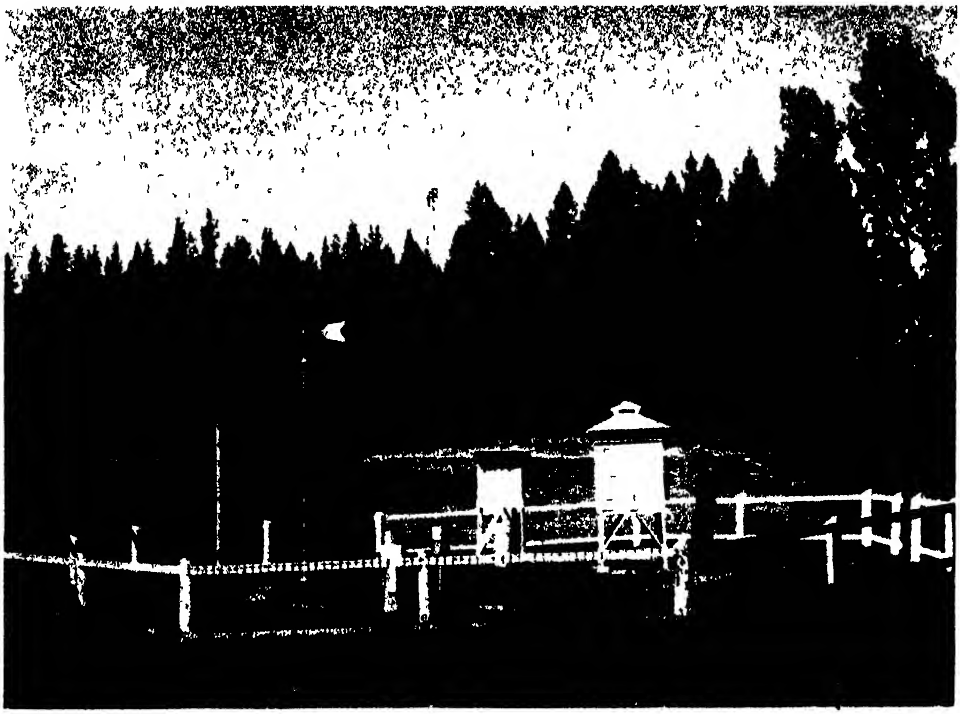
The research attack here has been largely on two phases—danger measurement and fire control planning, analogous to diagnosis and disease treatment in medicine The major factors of fire danger were first identified and integrated into a numerical scale by the Northern Rocky Mountain Experiment Station, which adopted, for the integration, a device called a danger meter Similar meters suited to local conditions have since been produced by the Lake States and Appalachian Stations, and a danger board employing tabular integration has been designed by the Pacific Northwest Station The California and New England Stations are expected soon to utilize similar principles to aid diagnosis of the current status of danger for their regions In all cases, the end-product is a numerical rating of fire danger, each class of danger signifying a specific size of fire control organization needed to furnish adequate protection

The scientific procedure here has been



A CORNER OF THE CHEMISTRY LABORATORY AT THE PRIEST RIVER STATION

CHEMICAL ANALYSES AND CALORIE PER GRAM DETERMINATIONS ARE MADE AT 10 DAY INTERVALS, MAY TO SEPTEMBER, FOR NINE SPECIES OF GRASSES, HERBS AND SHRUBS TO DETERMINE THE EFFECTS OF GREEN VEGETATION ON FOREST FIRE DANGER



THE PRINCIPAL METEOROLOGICAL STATION AT THE PRIEST RIVER BRANCH OF THE NORTHERN ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION TEMPERATURE, HUMIDITY, WIND VELOCITY, WIND DIRECTION, PRECIPITATION AND DURATION OF SUNSHINE ARE MEASURED AND RECORDED AUTOMATICALLY BY INSTRUMENTS IN THE FOREGROUND AND AT THE TOP OF THE 150 FOOT TOWER IN THE BACKGROUND

similar to that employed by Birkhoff[1] in originating esthetic measures. Positive and negative elements, formerly left to personal selection and evaluation, and therefore dependent upon "the idiosyncrasies of the individual mind," have now been identified, measured, integrated and reduced to formalistic theory susceptible of verification or disproof Administrative forest officers have contributed in many ways to this research, the intimate association of Forest Service administration and research aiding especially the field trials for verification or disproof. Such trials are now in their fifth season, in the northern Rocky Mountain region, and in no case, as yet, have the ratings failed to identify the higher dangers which have in the past cost so much in area burned over and resources destroyed

The second phase of fire suppression research, or fire control planning, was first studied by many administrative men, notably DuBois[2] in California Silcox stressed the need for research analysis of this phase as early as 1916 when he stated, "To approach anything like a satisfactory solution of the fire-protective problem, demands a clear thinking out of a plan or organization subdivided into its constituent, elementary parts" He identified these subdivisions as prevention, detection, control and finances, recognizing in the latter a

[1] G. D. Birkhoff, SCIENTIFIC MONTHLY, April, 1938, pp 351–357

[2] Coert DuBois, "Systematic Fire Protection in California Forests" U S Department of Agriculture (Not for public distribution) 1914

factor of basic importance which has since been frequently overlooked, and which has all too often been the major control of the prevention, detection and suppression action actually taken Show and Kotok followed Silcox with a research analysis of the California fire records evolving certain principles which determine "hour control" or the speed with which fires must be attacked Norcross and Norcross and Grefe contributed materially by their methodical treatment of the transportation elements basic to speed of attack Hornby, of the Northern Rocky Mountain Station, then developed his principles of procedure, which embraced all the old and many new factors and which by its methodology brought such work clearly into the classification of forest pyrology

Hornby's principles of fire control planning have revolutionized in many respects and have universally revitalized the former "rules of thumb" and individualistic procedures of determining how many detection men, fire chasers, suppression crews, etc, should be provided for any particular forest property Based upon the three definite fundamentals—values at stake, occurrence rate and fuel types—Hornby's procedures constitute a system reducing idiosyncrasies of individual opinion to a near minimum They determine not only how many men are needed for each class of measured danger, but also where these men should be located, consequently, where all lookout buildings, guard stations and many ranger stations should be built. These in turn determine the termini of all roads, trails and telephone lines both to service this organization and to permit it to "cover" its property most effectively Efficiency of "coverage" in detection and suppression was improved by 20 per cent without increasing manpower requirements for 17,000,000 acres of the northern Rocky Mountain region

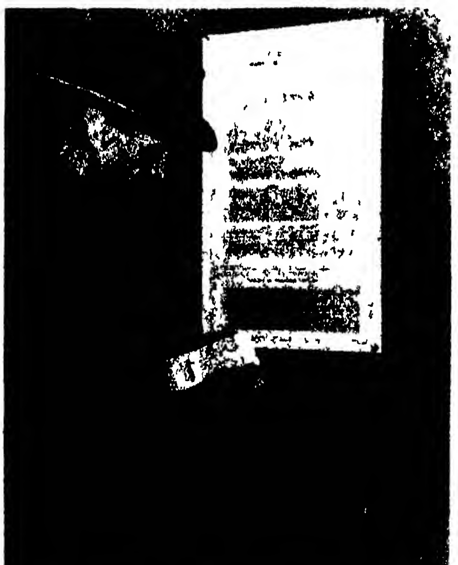
Studies of minor phases of this "coverage" were made at several other experiment stations, McArdle and Byram originating a highly efficient eye test for lookouts; Buck and Fons taking the visibility problem into the laboratories of the California Station for investigation, and Show, Kotok and others recently summarizing all features of fire detection in California Abell and Beeman and many others gave particular attention to visible area mapping, basic to lookout station selection and so important in providing adequate detection at minimum cost

Thorough investigation of chemicals to aid in fire suppression, an obvious opportunity for research, has been commenced by the U S Forest Products Laboratory with the cooperation of several experiment station and administrative units Results to date are promising for certain

A CORNER OF THE "FULL SUN" INFLAMMABILITY STATION AT THE PRIEST RIVER STATION THE MAN'S RIGHT HAND POINTS TO THE WOOD CYLINDERS, HIS LEFT TO THE DUFF HYGROMETER SPIKE OF THE ANEMO HYGROGRAPH, THE COVER OF WHICH HAS BEEN REMOVED TO SHOW THE CLOCK DRIVEN WEEKLY CHART OTHER TYPES AND SIZES OF WOOD CYLINDERS AND ONE OF THE FOUR LOGS USED IN STUDYING DISTRIBUTION OF MOISTURE IN WOOD ARE EVIDENT

fuel types, negative for others. The elimination of glow, and consequent rekindling, seems to be the chief attribute of chemicals

Studies of fire breaks as one control measure to prevent the unimpeded spread of fires and to constitute a battle front from which to work have been largely confined to California, the Lake States and the Southeastern States Chemicals for the permanent maintenance of fire breaks have been selected by the California Experiment Station, while the Lake States and Southern Forest Experiment Stations have made extensive tests of machine methods of fire break construction determining the principles of topographic location, width and depth of line and type of machinery



FIRE DANGER METER

FIRE DANGER FACTOR MEASUREMENTS ARE INTEGRATED INTO NUMERICAL CLASSES OF DANGER BY USE OF A SMALL DEVICE CALLED A FIRE DANGER METER (IN MAN'S HAND) THE CURRENT TREND OF EACH FACTOR, OF DANGER CLASS, AND OF SIZE OF THE PROTECTION FORCE ON DUTY ARE PLOTTED DAILY ON A DANGER CHART AT MORE THAN 120 FOREST STATIONS IN THE NORTHERN ROCKY MOUNTAIN REGION THE CHART ILLUSTRATED SHOWS A CASE OF POLICY OR FINANCES REDUCING THE PROTECTION FORCE EVEN THOUGH CURRENT DANGER HAD NOT DECREASED

(4) Fire Damage

Thorough investigations of fire damage in the California region by Show and Kotok, the eastern and southeastern states by Abell, Harper, Lentz, McCarthy, Nelson, Osborne, Stickel and others, and by Mitchell in the Lake States have definitely demonstrated that the obscure and indirect forms of damage are even greater than anticipated by the National Program The mere wounding of trees by fire not only depreciates butt-log values but eventually results in a high mortality due both to direct injury and to increased susceptibility to attack by insects and fungi In the longleaf pine region of the South temporary but complete exclusion of fire has been found essential to satisfactory pine regeneration Fires in turpentined stands of longleaf pine have been proven to be extremely damaging to gum yields and cupping materials. Indirect damages, such as water shortage, floods downstream from burned-over headwaters, and intangible or at least unassessable damages to recreation and wildlife or loss of labor markets in a community, due to the destruction of merchantable and near-merchantable timber, are not yet included as they should be in the so-called damage valuations

(5) Fire as an Agent

Artificially induced but perfectly controlled fever has been recently recognized by the medical profession as a beneficial treatment for several human ailments. Well-controlled fire has likewise been found by several experiment stations to aid in the treatment of many forest ills In both medicine and forestry accurate diagnosis and perfect control of the treatment are essential The use of fire to immunize the forest against fire has long been advocated, but frequently the cure was more dangerous than the ailment.

Scientifically controlled use has been found by research at the Southern Experiment Station, however, to aid certain forest types, (a) as a tree seedbed, (b) as a source of game and cattle forage and (c) in the reduction of some forms of disease. At the Lake States and Pacific Northwest Stations the beneficial uses of fire for fuel reduction have been weighed against the silvicultural damages, with the same conclusion as in the South, *i.e.*, fire should be used only by experts.

(6) Protection Standards

The National Program states that "the justification for fire research is primarily in its necessity for timber growing. Satisfactory timber crops cannot be grown unless certain definite standards or objectives of protection are attained."

Silcox[3] was among the first to state one protection standard as, "that system of fire protection which will hold the area burned-over each year to approximately one-tenth of one percent of the total" protected. Various other criteria such as percentage of class C fires, percentage of each timber type area burned annually and control by 10 A.M. of the next burning period have since been used as protection standards. None of these, however, is based intentionally upon all the social-economic objectives of forestry. None recognizes specifically the fact that forestry "works with folks as well as with trees and trails" and that "after all, folks are more important than firs." Since the National Program was written in 1926, the objectives of forestry have been greatly amplified, a beginning has been made in evaluating the social benefits of forest protection, the value of forest crops has been relatively minimized and the requirements of adequate fire control thereby very considerably expanded. This broadened concept of the functions of forest land management constitutes a new basis for the determination of fire control standards which deserves immediate and intensive research.

[3] F. A. Silcox, *Jour. Agric.*, University of California, Vol. IV, No. 3, 100–101, 1916.

DUFF HYGROMETERS

INVENTED SPECIFICALLY TO MEASURE THE MOISTURE CONTENT OF DEAD TREE LEAVES AND TWIGS COVERING THE FOREST FLOOR. THE SENSITIVE ELEMENT IS A PIECE OF RATTAN (PENCIL POINTS TO ONE) EXPOSED INSIDE THE VENTILATED SPIKE OF THE INSTRUMENT.

Conclusion

As Bailey and Spoehr[4] have stated:

All natural science is observational. During the earlier stages of its development, it concerned itself with describing and comparing the more obvious, complex, and grosser aggregates.

[4] I. W. Bailey and H. A. Spoehr, "The Rôle of Research in the Development of Forestry in North America." P. ix. 118 pp. The Macmillan Company, New York. 1929.

AN ELECTRICAL METHOD

IS USED FOR MEASURING THE MOISTURE CONTENT AT VARIOUS DEPTHS AND ON ALL FOUR SIDES, TOP, BOTTOM, EAST AND WEST, IN LARGE LOGS.

of matter and units of energy Through the analysis of large volumes of descriptive data, it succeeded in establishing many valid correlations between groups of phenomena. Subsequent search for actual causal relationships has led to the investigation of smaller and less complex aggregates or units, and natural science has resolved itself into a series of subdivisions, each of which deals with particular groups of phenomena and has developed its own specific observational technique

Research in forest pyrology, that subdivision of forest protection devoted to protection from fire, has in the past few years identified and isolated many of its particular groups of phenomena; developed numerous specific techniques for measurement, analysis, integration and correlation; and has originated distinctive methods of immunization, detection, diagnosis and control fully comparable with those of many other recognized subdivisions of science Forest pyrology is rapidly supplanting rule-of-thumb fire control and is now taking its proper place with the sciences of forest entomology and forest pathology for the better protection of our forest resources

LIGNUM-VITAE, THE TREE OF LIFE

By Dr. JOHN C. GIFFORD
PROFESSOR OF TROPICAL FORESTRY, UNIVERSITY OF MIAMI, FLORIDA

LIGNUM-VITAE—there is always an interest in, in fact, real history in a name The "wood of life" and why? We apply it to the *live*-oak because it is continuously green and virile, but in the case of lignum-vitae it was so called because it was at one time considered one of the most valuable medicines in all the world The gum of this wood has been in use since soon after the discovery of the New World, and its value as a medicine was, no doubt, learned from the Indians of the West Indies The wood once sold for many dollars a pound All the old medical books recommended it highly for gout, tonsilitis, neuralgia, rheumatism and syphilis Now it is hardly mentioned

Its generic name, *Guaiacum*, with four vowels in a row, is said to be of Carib origin The drug guaiac is obtained by soaking the sawdust and chips in alcohol Tears form on the living tree where it is injured, and the oil can be secured by boiling the chips in water The species found on the Florida Keys was named "sanctum" by Linné because he thought no doubt at that time that it was sacred, just as the Spaniards in the early days named cascara "sagrada." The latter drug still holds and is probably the commonest drug produced in the United States of North America, while lignum-vitae is now hardly mentioned in a modern materia medica Perhaps it has virtue as a remedy Many old things have, and it is hardly likely that it would have been used for so long a time without some results

One of the keys of Florida is called Lignum-Vitae Key because this tree was once plentiful there This key and Indian Key were used by Dr Henry Perrine for his introductions into Florida over a century ago, in fact, Indian Key was reputed to be the first port of entry in South Florida. I have found lignum-vitae on Big Pine Key, Key Largo and other Keys, but this interesting and valuable tree is slowly passing Although extremely hardy, like many other things when it starts to go it goes In the battle with axe and fire any tree must produce an immense amount of seed in order to survive In spite, however, of a constant demand a tree now and then may still be seen in secluded places. The wood is still

Photograph by Claude Matlack
TRUNK AND BARK OF LIGNUM VITAE.

sold by the pound and is probably the most valuable of all commercial woods. Because of its toughness there is probably no wood with a greater variety of special peculiar uses Aside from medicine its earliest use was in the manufacture of sheaths of ship-blocks In the days of sailing vessels these blocks were essential, and we all know that for many years the woods by tidewater in Florida were used for ship construction by at least three nations, not to mention pirates and their kind that were outlaws I have no doubt but that the tidewater timbers of Florida were exhausted more than once by people of many nationalities who came and went Timbers of all kinds for ships must have been in demand for a long time There must have been a feeling of scarcity, otherwise they would never have established a live-oak reservation at Santa Rosa near Pensacola over a century ago Of all the special parts of a ship demanding special woods none was more important than the ship's blocks, through which the ropes could run easily and without the danger of breaking under stress

Its modern use is of equal interest The steel ship has superseded the wooden vessel Propellers have replaced sails What is now the most important use of this wood is for bushing-blocks for propeller shafts of ocean steamships A wood must be tough to serve for such a purpose and the natural oil in the wood helps, although the constant turning of these great shafts under the water of the ocean millions of times in covering many thousand of miles is one of the most trying services to which wood or any substance could be subjected.

In the backwoods of Cuba many years ago I was shown a cannon of wood The natives were short of materials of all kinds except what their patches of cleared land and the surrounding forest produced They bored a hole in a lignum-vitae log They wrapped this log with green rawhide. The hide in drying grew

tighter to help hold it together. They loaded it with bullets of some kind and black powder of their own manufacture. Although they assured me that it had been successfully fired several times, I did not wait for a demonstration.

To-day it serves for mallets, tenpin balls, castors for furniture, brush backs and a host of similar uses

I have always admired this gnarled, round-headed tree Its wood fibers are interlaced in such a way that it never splits. It is short and stout and appears in the shade in mixture with other things. It is of slow growth and is often found on very poor lime rock The tree in some places looks as tough as its wood It has a compound leaf three or four inches long with the leaflets arranged in three or four pairs It is often fresh green when other things have been seared by drought. Three or four flowers are produced at the ends of the branches They are under an inch in diameter but are delicate The petals vary in shades of blue It is a highly ornamental tree for the yard, and I have often thought that it would form a sturdy hedge The fruit is roundish, less than an inch in diameter and usually bright orange when ripe. Inside are black seeds covered with a scarlet coat.

From the standpoint of use association through the years it has few, if any, peers As a plant for future use in landscape architecture and forestry in the tropics it probably should have an important place It is just one of those old-time trees in Florida which is slowly passing, unnoticed and unsung Of course, over in the West Indies there are still many trees and it will probably be a long time before it is completely exhausted, but in the state of Florida it will soon be a thing of the past unless rescued by those who are interested in the preservation of native things

Photograph by Claude Matlack
LIGNUM-VITAE TREES ON KEY LARGO.

Photograph by Claude Matlack
LEAVES AND FLOWER
OF LIGNUM-VITAE ALSO SHOWS IMMATURE FRUITS

AN UNWRITTEN CHAPTER IN THE PHYSIOLOGY OF AGEING

By Dr. A. J. CARLSON

FRANK P. HIXON PROFESSOR OF PHYSIOLOGY, UNIVERSITY OF CHICAGO

THE information available to-day on the longevity and the causes of death in man, as well as in animals, indicates that the primary factor or factors in longevity are hereditary. That is to say, even if we had a total absence of infectious disease, an optimum diet and ideal conditions for life and work, and even if we knew how much and how little physical and mental work is the optimum for longevity, man and animals would still grow old, grow feeble and die But there is no doubt that were ideal environmental and dietary conditions obtainable, man would reach a longer life span than he does at present

There is also some evidence, both in the case of man and of other animals, that this hereditary time-clock or power of living varies considerably in the different organs of the individual, and since all organs are more or less necessary for living, the weakest organ becomes the weakest link and thus determines the life span of the individual. The primary hereditary nature of this organ time-clock is at present not readily differentiated from the factor of injury to individual organs by environment. The endocrine organs have by many been considered as such timers of the life span, and it is true that some of these, like the adrenals and the pancreas, if not the parathyroids, are absolutely necessary for life It is a curious fact that the endocrines (the ovaries and the testes) that are by many laymen and many ill-informed physicians considered to be the primary time-clock of life and around which the whole pseudo-science of rejuvenation has been built up during the last generation, are apparently not one of the links that determine the life span of the individual In other words, there is no evidence that early castration or spaying shortens the life span or that the life span can be prolonged by prolongation of the life of the gonads or by judicious administration of the hormones of these glands Of course, it is well known that the gonads determine the level and duration of the period of life devoted to reproduction.

One of the important systems or links in the life chain is the heart and the circulation, and in the majority of people who live beyond 60 or 70 years, there is definite impairment of the heart and circulation, and death due to such impairments mount very high at this period How much of this cardio-vascular failure in old age is the plain wearing-out of the hereditary machine and how much of it is due to the accidents of life, to infections, to faulty diet, to over-work or under-work, to emotional over-strain is still an unwritten chapter in biology and medicine, to which should be devoted well-planned and long-time research. In exceptional individuals living to the age of one hundred years or more, the vascular system at that period may still be adequate for the strain of life, and the cause of death may be an accidental infection of other systems, like the lungs But this is the important consideration in connection with the heart and the circulation · This system determines the adequacy of the internal environment, that is, the blood in its relation to every tissue in the body. Consequently, any serious impairment or failure in the cardio-vascular system will be reflected as an impairment of the activities of every organ in the body, including that of the

resistance to disease and the efficacy of the several immunity mechanisms.

Despite this primary hereditary time-clock of longevity as shown in plants, all species of animals, as well as man, there is no question that unfavorable environmental factors can themselves shorten the life span Indeed, it may be true, but we can not at present assert it as a general fact, that part of the hereditary factors in longevity consist in the capacity to overcome, resist or adjust to unfavorable environmental factors These unfavorable environmental factors may be classified largely in the following four groups

(*a*) *Infections* Some of these leave greater scars and impairments than others, but I know of no evidence to the effect that any infectious disease is favorable to longevity

(*b*) *Diet* We do not yet know what is the optimum diet for health and longevity at any age of man But there is no question that quantitative and qualitative dietary deficiencies, if long continued, impair many organs of the body and therefore probably shorten life. And all the evidence we have to-day indicates that overeating and under-exercise, in the physical sense, are also injurious To be sure, Professor McCay, of Cornell University, has in recent years shown that the life span of the white rat can be considerably prolonged when the animals are put early on a qualitatively adequate but quantitatively inadequate diet, so that their growth is retarded for one or two years But we are not as yet justified in transferring these results on rats to the human species and keep our children retarded in growth until the age of thirty or thirty-five McCay's experiments do tend to support the theory that the life span is determined in part by the rate of primary living, that is, the oxidative and the growth rates of the body

(*c*) ***Work*** As with the diet, we do not yet know what is the optimum mental and physical work for the most complete realization of the hereditary potentialities of longevity. No work at all seems to lead to adiposity and degeneration. Excessive physical work can apparently cause degeneration by exhaustion But as we have, at least in the case of many of the organs, tremendous factors of safety, much physical and mental overstrain can be indulged in for very long periods before life is jeopardized But this is largely an unwritten chapter The chapter can not be written without further well-conceived and long-time research From the point of view of society and civilization, work is more important than is longevity for the individual, and efficient life is more important than long life I regard it high time that society concern itself seriously with research on this problem

(*d*) *Poisons* And lastly, we have the disturbing factors that may be briefly classified as the *poisons of civilization* I don't refer to propaganda and hate and falsehoods and war I refer to the actual chemical poisons of civilization Our continued advance in chemistry, physics and engineering releases environmental conditions to which our forebears, primate and animal, were not subjected for millions of years We have such things as alcohol in drinks, alkaloids in soft drinks, nicotine in tobacco, lead, arsenic, fluorine and other poisons on our vegetables and fruits, toxic chemicals in our canned foods, new and injurious chemicals blown into the air we respire by the smoke that goes up nearly every chimney of civilization To-day we can recognize and diagnose and to a certain extent ameliorate acute and advanced chronic poisoning from such factors But what injury to our living machinery is produced by these poisons of civilization before thus recognizable is one of the unsolved problems of medicine, society and government facing us to-day and to-morrow

In brief, then, what is to be done about it?

The medical profession has its hands full, both to-day and to-morrow, in the matter of preventive medicine, in the way of prevention of infection, in prevention of dietary deficiencies and in prevention of over-strain, mental and physical. In this connection, we may note that an optimum environment is probably not attainable. The profession could and should take the lead in guiding society and government in the lines of research necessary for the wiser and healthier life of to-morrow

The medical profession has a further duty in the line of education of our fellow men along the line of practical realism and understanding of the nature of life and disease Physicians stand accused of being the main agency in the present-day civilization of preserving unfit human beings Maybe they should pay a little more attention in the direction of better environment for those best fitted by heredity At present a discussion of eugenics is largely academic. Society is not ready for it. We probably do not know enough to enforce the principles wisely, but there seems little doubt that eugenics could and should eliminate reproduction in individuals with the weakest hereditary time-clocks in their make-ups.

HIGH BLOOD PRESSURE

By Dr. EDWARD J. STIEGLITZ
GARRETT PARK, MARYLAND

WHAT is this thing called "high blood pressure"? The term lies glibly on many tongues Business men discuss it at lunch or in the club locker rooms, women tell of their blood pressure at bridge or sewing circles. A fascinating subject, made even more alluring by unconscious and misleading superficiality, for almost all the "facts" and fancies discussed are woefully wrong. The most ponderous oracular utterances by the elder at the club may be impressive, but they fail utterly to approach the truth of the matter There are more false notions in the air than birds Even among physicians there is a deplorable lack of understanding of the many aspects and problems of hypertension, popularly called high blood pressure. It is sadly true that our knowledge is still incomplete, but we can, at least, set straight that which is known.

America has become blood pressure conscious through its pocketbook. If the approach to a man's heart is through his stomach, then certainly the approach to the American mind is via its wallet. The one thing, more than any other, which drives home the importance, if not the significance, of high blood pressure to a business man is his rejection as a risk for life insurance And life insurance companies are tightening their requirements and becoming increasingly unrelenting in these rejections Of all diseases to which adult man is heir, the "cardio-vascular-renal diseases" (namely, that group including heart exhaustion and diseases of the arteries and kidneys) are the most frequent cause of death today Heart disease is very often but a part of a generalized disturbance of which high blood pressure is the major warning Sanitation and preventive medicine have done much to advance life expectancy, and as a result the illnesses and disturbances of middle and later life are of constantly increasing frequency. With every child saved from typhoid fever, "summer complaint" or diphtheria there is another adult potentially a victim for these later disturbances. Census data reveal a gradual but appreciable shift in the average age of our population to-

ward the older age groups; there are proportionately more people of 50 years or more now than there ever were before. The rapid pace of present-day civilization, the augmented complexity of existence and the anxieties of the competitive struggle to find security in a rapidly changing experimental social structure emphatically contribute to the excessive wear and tear so responsible for many premature deaths

But the true tragedy of hypertension lies not alone in its frequency, not in its silent insidiousness nor in its ultimately high mortality, but in its misfortunate selection of victims

The incidence of hypertension is increasing It is difficult to determine accurately In American males under forty-five years of age the incidence of hypertensive disease is in the neighborhood of 8 to 10 per cent. Above this age the frequency rises sharply for both sexes, so that in the sixth decade the frequency is of the order of 30 per cent of the population Hypertensive disease is characteristically a disease of those whose energy, productive imagination and sense of responsibility make them most valued citizens In an age where more than ever before the fundamental and irrevocable laws of nature are being violated by gallantly chivalrous and politically motivated paternalistic aid for the relatively unfit, the survival of the spiritually, intellectually and physically fit becomes increasingly jeopardized The workers shall labor for the drones A wise policy, perhaps, in a community of bees or ants, but archaically naive and stupidly short-sighted in a civilization composed of presumably thinking men. The deliberate and consciously induced disrespect for the wisdom and experience of age gives the fresh impetus to the arrogance of ignorance and violence to the demands of short-sighted selfishness. Witness the almost incredibly rapid spread of the insolent phrase "the nine old men" and the truly vicious teaching of the implied disrespect.

Hypertension, although most frequent among the true aristocracy of doers and givers-to-humanity, is not limited to any one class of men. It appears, increasingly, in all walks of life The free clinics and dispensaries of our large medical centers are overburdened with derelicts, incapable of work if it were available, whose disability arises from high blood pressure Although more frequent and usually more rapidly progressive in men, it is a common problem in women, particularly at or after their "change of life" Hypertension is a most vital problem in pregnancy and is never to be taken lightly, it is a part of those poisonings of pregnancy which cause about one fifth of all our maternal deaths.

The mortality of hypertensive disease is high, although the course of the disease is usually slow and silent over a period of many years Conservative estimates place the annual number of deaths in the United States, from this one cause alone, at over 150,000 Although numerous persons with hypertension live many years in apparent health, the average life expectancy is greatly shortened The disability attributable to this silent and unobtrusive assistant to the Great Reaper is even greater cause for our concern. Many patients with high blood pressure live for years as partial or total invalids, a burden to themselves and to those about them, and with the threat of sudden death ever before them High blood pressure is responsible for the great majority of heart invalids over fifty years of age Furthermore, approximately one fifth of the deaths result from apoplexy and many more patients have non-fatal but disabling strokes

All this presents so truly alarming and pessimistic a picture that one is tempted to adopt a futile fatalism as the easiest way out That would be utterly wrong

There are other sides to the picture (as there *always* are and as can always be found by conscientious search for truth, except by misguided zealots with preconceived notions, who must close their eyes and minds to all which does not coincide with their fancies) The rate at which the disease progresses varies greatly in different individuals Its course, even when neglected, is painless and often so slow that it progresses over twenty years or more before tragedy intervenes If discovered relatively early, hypertensive disease can usually be controlled and thorough and competent medical guidance can add many useful, happy years to the span of life It is the very painlessness of the disorder which makes it dangerous, for it encourages neglect and postponement of the careful study necessary for effectual medical management Then, when it is too late, when the damage done is irrevocable and irreparable, the patients expect, nay, even often demand, that the physician casually shake a miracle from his sleeve!

But, you may well ask, what *is* high blood pressure? How does it come about? Why does it occur? Are all instances similar? How does it cause damage? What are its consequences? What can one do about it and how effective is this doing? We shall try, within the limits of a non-technical exposition, to attempt to answer some, if not all, of these questions and disabuse the vague, misleading and semi-superstitious misconceptions now so prevalent.

Firstly, let us correct the most common fallacy High blood pressure is *not* the result of "too much blood" The tenacity with which this untrue idea is retained in the popular mind probably relates by association to the ancient but misguided treatment by bloodletting Although hypertension is by no means a "new" disease, its recognition is relatively recent It is only since about 1900 that practical, simple and accurate methods of measuring the blood pressure in man were contrived About seventy years earlier the first more clumsy and incomplete instruments were devised. As knowledge concerning the mechanisms of the circulation gradually accumulates and truth slowly comes out of darkness, it is realized that much of the previously acquired "information" is false and misleading and must be discarded and a fresh start made It is not easy to unlearn errors It can be said that the data and ideas concerning hypertension which antedate 1905 are largely valueless, almost all our present understanding has been arrived at in the last thirty years, and to-day, as always, these concepts are in a continuous state of flux and revision What we use as true to-day may be proved wrong to-morrow But in the meantime we must *use* these tentative truths as tools to make better ones

To outline the mechanisms of hypertension, or high blood pressure, it is necessary first to explain briefly something of the normal processes of the circulation Disease does not involve new processes, but exaggeration or distortion of the normal mechanisms The purpose of the circulation is to supply all the cells of all the tissues of the body with food, building material and fuel The fuel is oxygen, taken up by the blood in the myriad of air saclets of the lungs, and food materials from the intestinal canal. In order to reach all the cells, these final, finest delivery channels or vessels must be extremely small and ramify in a close meshwork so that no one cell of the body is at any great distance from a vessel Such minute ducts are called "capillaries" and correspond to the by-streets, alleys, courts, passages, water pipes and sewers of a colossally gigantic city so that each and every "inhabitant" thereof may receive his share of nutriment and get rid of the garbage of his existence. Just how many million miles of these minute vessels exist in a man has never

been computed. Of necessity the walls of the capillaries are exceedingly thin to permit of ready and rapid transfer of oxygen and food from the blood to the cells and *vice versa,* transfer of debris from the cells to the blood

Between these tiny, microscopic channels and the larger, visible, thick, pulsating arteries such as those we may feel at our wrist and which may be compared with "ultra superhighways" of the colossal community of cells, there are many, many miles of "through streets" or "arterial highways" whose average size is such that from 400 to 800 of them side by side would be an inch thick These are called "arterioles" or little arteries. The arterioles serve several purposes, each vitally essential to the body Their walls are relatively much thicker than those of the capillaries The walls are largely composed of muscle cells which lie wrapped about the bore of the vessel in close spiral formation. These muscle cells resist stretching and therefore give strength to the vessel walls, and they also may contract, narrowing the bore of the tube.

The arterioles have, in addition to the usual function of being smooth ducts to carry the blood, two fundamentally important activities. They interpose a dam between the indispensably higher pressure and rapid flow of blood in the arteries and the low tension and necessarily leisurely movement of the blood in the swamp-like channels of the capillaries Behind this dam of arterioles the pressure of the blood is considerable, below it low Therefore, they are a potent force in maintaining the arterial pressure and in preventing collapse of the circulation

It becomes obvious how inadequate is the term "blood pressure," for at different levels of the circulatory tree the pressures are different. We can and should speak and think of "capillary pressure," "arterial pressure" or "arterial tension" and "venous pressure," to be clearly precise The terms "blood pressure" and "high or low blood pressure" have, by usage, been used to designate the arterial tension, but such usage is loose, confusing and undesirable. To maintain a normal and adequate circulation in the capillaries is the prime motive of all the rest of the circulatory machinery, and to do this a sufficient head of pressure in the arteries is necessary. This head of pressure is sustained by the propulsive force of the heart on the one side and the peripheral resistance offered by the minute spiral muscle cells in the walls of the arterioles on the other Other factors enter into this conflict of forces, but they need not concern us here Death quickly intervenes if the tension is not maintained To say "Have I a blood pressure?" is as ridiculous as to ask, "Must I breathe?" It is only when the pressure becomes abnormally high or abnormally low that it becomes a menace.

The second auxiliary function of the arterioles is *to control the distribution of the blood.* The demand for blood on the part of the cells is not a constant requirement, but varies with the amount of work being done. For example, after a meal there is a greatly increased demand for blood in the organs of digestion; with walking or running the leg muscles require many times the amount of oxygen they use at rest, or on thinking the brain consumes much larger quantities than during sleep These perfectly normal fluctuations or "rush hours" are taken care of by the arterioles during digestion the vessels in the stomach and intestines relax and the flow of blood through the capillaries is greatly increased As this happens there occurs a compensatory constriction of the arterioles elsewhere in the body and the circulation as a whole is but little disturbed As the "rush hour" of digestion demands an appreciably larger share of the supply of blood, other structures must get less at that time This explains the drowsiness which comes over us after a hearty meal or the inability to

exert violently during digestion. To attempt severe mental or physical work during digestion invites inefficiency for *both* the digestion and mental or muscular activity.

Thus the arterioles are in a constant state of variation and adjustment of the blood flow, both locally and generally Their muscular walls are continually relaxing or constricting slightly to maintain an equitable distribution of blood to the tissues. The tone or degree of tension in the spirally arranged smooth muscle cells of the arteriolar walls is under the control of a complex meshwork of automatic nerves There is no conscious control of the vascular tone, nor any consciousness of the state of tension within the vessels Thus it is possible that an individual may be walking about with a blood pressure of twice the normal and still not be conscious of it.

Of the almost innumerable illustrations of arteriolar activity which might be cited, two will suffice The old-fashioned blush is nothing more or less than a temporary relaxation of the arterioles of the face and neck so that there is a transient increase in the flow of blood under the skin and hence the red hue Blanching on exposure of the skin to cold is its converse The "angry red" zone about a localized infection such as a pimple or small boil is due to arteriolar relaxation in that area, this fulfills the purpose of bringing more blood to combat the invading bacteria In both these illustrations the change in caliber of the arterioles occurs in limited areas and because of the balancing constriction of arterioles elsewhere in the body there is little or no appreciable change in the general circulation, the blood pressure is unaltered

Increase in the blood pressure *arises from a generalized increase in the tone or constriction of myriads of arterioles* In the development of the disease of which increased blood pressure is the major and characteristic change, there is, at first, a gradual and intermittent increase in arteriolar tone As the arterioles constrict slightly the blood flow in the capillaries is diminished and, simultaneously, the resistance to the flow of blood from the arteries is increased It is as though there were a partial closing of the sluice gates of a dam So, *behind* the arterioles the circulation is lowered The greater the constriction or obstruction the higher the arterial pressure and, what is more important, the poorer the flow of blood in the tiny but life-sustaining capillary networks

As hypertension first develops, the constriction of the arterioles is intermittent and variable; the blood pressure frequently is quite normal but rises to higher levels temporarily. It is normal that the blood pressure vary under certain circumstances such as anger, effort, fear and the like, but in these individuals the rise is exaggerated These more violent fluctuations are extremely important, they forewarn that in the future the pressure will tend to remain at higher levels and that the temporary ascensions will become greater and greater We can now see why a single, isolated observation of the blood pressure can be dangerously misleading, neither a single normal reading nor a single observation of elevated tension is significant until we know what the average and habitual behavior of the blood pressure is under varying circumstances It is as though we were to conclude that the pulse is perfectly normal because it is found so after an hour's nap, after exertion or excitement it might behave most outrageously

With the passage of time the increased tone of the arterioles becomes more and more continuous; the minute muscle cells are more and more constantly contracted and the caliber of the arterioles persistently narrowed Now the blood pressure is more unceasingly elevated Struc-

tural changes in the arterioles begin to take place Use stimulates tissues to grow Exercise causes greater development of muscle. Thus the arteriolar walls gradually become thickened by growth of the tiny muscle cells; they become both larger and more numerous As the arteriolar walls become stronger their ability and tendency to constrict becomes greater, so that the increase in tone is further enhanced. A vicious circle is engendered The arterioles are now constantly somewhat narrowed and at the slightest excuse they contract still further Thus the blood pressure is continuously increased but subject to acute and often rather violent fluctuations still further upward

But it is characteristic of muscle cells that they are not adapted to continuous contraction Muscles function efficiently only when their contraction is intermittent This is quickly demonstrated by the difficulty encountered on holding one's arm horizontally for any length of time; fatigue quickly ensues Whereas one may lift and lower the arm many times without exhaustion, continuous elevation soon becomes irksome because of muscle weariness The continuousness of the arteriolar contraction gradually and almost imperceptibly causes fatigue and then exhaustion of the muscle cells As this continues, a few muscle cells in the arteriolar walls become exhausted and die Their places are taken by scar tissue This scar tissue is neither elastic nor does it have the power to contract as does muscle. The tiny arterioles become stiffened and narrowed; the blood pressure is continuously raised to high levels because of this obstructive narrowing of the sluice gates. This latter type of change in the arteries (arteriolarsclerosis) is permanent and irrevocable.

This then is what happens with long-continued high blood pressure The whole progression takes years to develop to the point where the scarring of the arterioles is advanced and unchangeable. It may be twenty or more years from the beginning of the disturbance, in some few especially violent and rapidly advancing cases but one to three years elapse All grades of severity and rates of progression are found. The almost imperceptibly slow march of events is tenaciously persistent. There is no tendency toward arrest of the advance. It is free from pain throughout Usually there is no consciousness of any appreciable change

Why then be concerned with efforts to arrest the progress of this silent, painless disease which is so harmless in the early stages? Because it is *only* in the early stages that anything can be accomplished, and because, when the damage is done to the vessels, the patient is in constant jeopardy It is then too late to perform miracles Thus the very essence of the problem is early discovery, early treatment to arrest advance and prevent or, at least, greatly postpone, the ultimate, inevitable termination

Recalling, for a moment, the description of what bodily changes take place to create an increase in the blood pressure, we are conscious of the disintegration of certain popular myths and false ideas Firstly, it is clear that thickening of the arterioles is less the cause of high blood pressure than the result thereof. Secondly, the disease is not one of the blood, but of the arteries and arterioles Hypertension is not the disease; it is a *symptom* or sign of the affection of the vessels The term "hypertensive arterial disease" is particularly apt. It is of great importance, for the sake of clarity, to distinguish the one from the other; they are much confused even among physicians Hypertension, or the state of high blood pressure, may exist without the disease, under conditions of temporary arteriolar constriction The disease

develops only after the increased tension of the vessels has continued long enough to induce the aforementioned changes therein.

Thirdly, it becomes evident why early in the course of the disorder the blood pressure is extremely variable (during those phases where the arteriolar muscle is growing under the impetus of increased activity) and quite "fixed" later when scarring of the vessels has occurred The "fixedness" of the blood pressure is a better guide to the condition of the vessels (the essential question) than the mere height of a single measurement It may be a most desirable omen that the blood pressure fluctuates widely

Fourthly, we have seen that a great deal depends upon the character and quality of the arterioles. It was in this connection that the great Sir William Osler used the expression, "the quality of the rubber" The toughness of this arteriolar "rubber" to withstand the repeated shocks and insults of existence and the increased burden imposed by hypertension largely determines how long it will last. That the "rubber" is not all that it might be in instances of hypertensive arterial disease is shown by the fact that hypertension develops That is in itself evidence of inherent weakness or vulnerability This vulnerability takes the form of increased responsiveness to stimulation or irritation Irritants which have little effect on normal persons cause exaggerated constriction of the arterioles in those "vulnerable" ones who develop hypertension This susceptibility is inherent and permanent, it is as much part of these people as are the color of their eyes, their tastes or the shape of their hands It is essential that this be kept in mind, because, although one may arrest the progression initiated by *one* source of irritation, that does not prevent recurrence of the disturbance from other sources. The vulnerability of these patients permits of frequent recurrences and exacerbations or "flare-ups" of the hypertension It is as a turned ankle, more likely to be sprained again, even with relatively little insult.

Two of our questions are now answered We've seen what high blood pressure is and how it comes about But, *why does it occur?* That is not as readily explained It is so easy to ask "what is the cause of high blood pressure?" and so difficult to give a scientifically satisfactory answer that most physicians shelve the whole problem by replying "The cause is unknown" That is not true Much, but by no means all, is known In recent years there has been considerable progress made toward the solution of this vexing problem Scientific progress is slow, and is the product of many minds and labors Exploration into the unknown realms of science (and this applies not only to medicine and biology, but to all science), is a matter of cooperative effort by many workers, each taking but one step forward at the time, the combined steps into the gray void of ignorance slowly bring light thereto, and the unknown becomes clear There are few whose vision penetrates far through the haze, nature's secrets are well guarded by a shrouding mist or fog and through this mist we must penetrate, checking and rechecking each slow forward step so that false assumptions may be avoided. That a few are gifted with penetrating vision to see far through the haze and open whole new continents of thought and knowledge is the inspiration of the many workers. Darwin was one such, Pasteur another To venture into the realm of the scientific unknown is to combat fog Fog is the occasional lot of the geographic explorer, in other forms it is the usual and habitual handicap of the biologist. Fog is all-enveloping, gray, almost impenetrable, distorting distance and size and shape. The infinite varia-

tion that occurs in life makes generalizations extremely hazardous.

It is false logic to assume that there is but one cause of high blood pressure There are many There always are. Events and consequences, be they disease of man, economic waves of lavish prosperity or desolate famine, wars, tyrannical exploitations of whole nations or the petty scandals of the crossroads, result from the interaction of many forces, some recent, some passed, some apparent, even obvious, and others, darkly obscure. To deny the existence of these forces which are obscure just because we, as yet, can not see them all, is worse than folly, it is prostitution of our heritage of intelligence.

Hypertension may be likened to the breaking of the camel's back. The fable says it was the last straw which broke its back, ignoring the equally important weight of all the other straws! And the previous load may not have been straw at all, but bricks or hay or dates! To understand the "why" of disease (and certainly a broken back is a major illness) the first essential is to recognize the infinite possibilities of multiple insults and that each and every example may have a different set of injurious factors.

Many of the causative factors responsible for high blood pressure are known They fall into three categories—predisposing, provoking and perpetuating factors. This classification of causative influences is applicable to any disease. For example, although we know that influenza is "due to an infection" we also have come to realize that even more significant is the depletion of the patient's resistance through fatigue, exposure, anemia and the like, prior to the exposure to the microbes. It is this depletion of resistance which makes possible the invasion by the infecting agent Or, we may take as an example the problem of flood control, if the dykes or levees are in good repair no flood will occur unless the rise in the water is extraordinarily high, whereas a small rise in level will cause floods if the dyked banks are weakened through neglect

In hypertension the predisposing factors are of the greatest importance To repeat Sir William Osler's quotation, much depends upon "the quality of the rubber" The hereditary and familial background determines this. Hypertensive arterial disease frequently "runs in families" It is not implied that the disease itself is transmitted by heredity: the vulnerability is inherited. That is why physicians take the pains to inquire into the "family history" despite the usual incompleteness and inaccuracy of such information Most of us are woefully ignorant of the medical aspect of our family background. I wonder how many of us can accurately state the cause of death of all four of our grand-parents. I know that among my medical students only about 10 per cent can answer that question. And yet that represents but two generations back. Breeders of fine animals know all too well how inadequate such brief genetic history would be in developing superior stock. The absence of known evidence of arterial disease is no proof of absence of the disease Negative evidence is never proof. Because John can't find his collar button does not prove the collar button doesn't exist

Personality has considerable bearing upon the occurrence of high blood pressure. Nervous control of the arterioles, although automatic and not under conscious or "voluntary" control, is markedly affected by the status of the higher nervous centers. Fatigue is a curious two-edged phenomenon; it may depress as it approaches exhaustion or it may stimulate by reducing the affectiveness of a balancing mechanism. It is most difficult to appraise fatigue of the nervous system.

The hypertensive individual frequently conforms to a characteristic personality

pattern. It is extraordinarily perplexing as to whether certain psychic characteristics are responsible for the development of hypertensive arterial disease or are a result thereof. Probably both relationships are true The typical hypertensive personality is aggressive, enthusiastic and active. These people are doers, are forceful and restlessly ambitious. They tend to work continuously, knowing not the value of mental relaxation, for they are obsessed with a conspicuous singleness of purpose Absorbing hobbies are shunned as being "a waste of time" rather than being recognized as valuable. Games are taken seriously and with the typically American intensely combative spirit of competition Frequently the ardent will to win leads to eminent success in their chosen careers, but this is accomplished at an extravagant cost in physical depletion These personalities resent inactivity and delay; calm adaptation to the irritations of existence is replaced by a shortened, explosive but effervescent temper Whenever things go wrong they must "*do* something." Characteristically, they are keenly conscious of responsibilities and appear to seek additional burdens They are temperamentally "habitual worriers"; this is the most common trait They are not truly pessimistic nor tranquilly fatalistic.

The most significant and frequent characteristics are the tendency to habitual worry, the increased consciousness of responsibilities, the consuming anxiety for success and the inability to relax It is consequential that all these outstanding psychic traits contribute to fatigue Such fatigue of the nervous system may be a potent factor both in predisposing toward hypertension and in the perpetuation of the processes in constitutionally vulnerable individuals

There are countless provoking factors which may start the arteriolar constriction of hypertensive disease. The initiating factors include "anything which, over a long period of time, irritates or stimulates the arterioles" Such an inclusive statement requires amplification Almost invariably there are several super-imposed sources of injury to the arterioles Each and every case of hypertensive disease presents a new and individual problem in finding the causative influences. We know of many of these factors, but not all Therefore, it comes about that occasionally one must, even after careful study, admit that the cause is undiscovered But that does *not,* as so many defeatists declare, imply that there is no cause

The known provoking factors group themselves into several categories: Infectious factors, chemical poisonings from without, chemical poisonings from within and nervous factors Among the infective factors two stand out preeminently. There are influenza and long-neglected foci of infection such as at the roots of teeth, in tonsil stubs, chronic sinus infection and the like. In such instances it is not so much the intensity of the infection as its long duration which is important Influenza or la grippe is a treacherous and misleading malady. Its most characteristic attribute is that its sequelae or "hangovers" are all out of proportion to the apparent severity of the acute illness A few days of seemingly mild "flu," with perhaps but 48 hours of fever, is followed by four to eight weeks of both mental and physical lassitude and weakness As one patient put it to me: "The limp dish-rag feeling" These are but the obvious consequences of "flu"; far more important are the silent, insidious injuries to the vital structures such as the heart, kidneys or blood vessels Here again the physician is frequently led astray by unintentional misinformation; the hypertensive patient has sincerely forgotten, and thus failed to mention, the "mild" attack of "flu" which laid him abed for three or four days some

years previously And such latent injury is far more likely to those of the hypertensive personality; their restless ambition is so short-sighted that it does not permit them to take adequate time for convalescence and repair after an acute infection

Among the chemical sources of injury to the arterioles are lead and arsenic Mild degrees of chronic lead poisoning are far more common than is generally realized. It is not limited to industrial workers Unwise dietary habits may play a role, particularly significant are the abuse of condiments and spices and an habitually insufficient intake of water The "hot" oils of the spices which burn our tongue also irritate the arterioles and the kidneys, although we don't feel their smarting there The highest arterial tension I observed (360 millimeters of mercury) occurred in a young woman who had, for several years, consumed two to four bottles of Worcestershire sauce per day, undiluted She liked it, but it contributed to her most untimely end. Other dietary factors are less important but may contribute if far out of line with the normal balanced ration Alcohol is rarely a factor In a few instances tobacco may be productive of arteriolar irritation, in certain susceptible individuals The susceptibility to tobacco smoke is extremely variable

Illustrative of chemical injuries arising from within are certain distortions of the glands of internal secretion (high blood pressure arising at the change of life in women is quite frequent), the poisonings associated with kidney injury, the chemical imbalance that may accompany pregnancy and last, but not least, fatigue Fatigue should be considered as much a poisoning or intoxication as inebriation, only it is hidden both from the sufferer and those about him. Long-continued nervous and physical fatigue in conscientious individuals, continuously and keenly conscious of their many responsibilities, is a factor which can not be ignored Thus it is that so frequently those who carry the greatest burdens of a community's welfare succumb to high blood pressure

Kidney injury usually produces no symptoms which warn the patient that these vital structures are failing to do their work properly Even examination of the urine may be unsuccessful in revealing the extent of damage We start life with a wide margin of safety in kidney capacity to rid the body of noxious substances, this extra reserve is gradually reduced as we go through life, sometimes slowly, sometimes rapidly Just because it is the major function of the kidneys to rid the body of excesses of chemically injurious substances, these structures are particularly exposed to injury Acute infections frequently cause undetected kidney impairment, the acute contagious diseases such as scarlet fever, diphtheria and the like are the most common sources of silent damage in youth Such damage may exist for years without sufficient manifestations to drive the patient to a physician, then, in the years usually classed as the prime of life, the kidneys fail utterly and life is but a matter of months Injury to the kidneys from any source is one of the frequent provoking factors in the causation of high blood pressure Detection of such injury and measurement of its extent and significance requires careful, thorough, painstaking study by the physician. These are not questions which can be properly answered in a few minutes.

These are some of the reasons why high blood pressure arises It is obvious that each and every instance of the disease is an individual problem and requires individual study and attention.

Hypertensive arterial disease causes damage by interfering with the normal and required supply of blood to the tis-

sues of the body The narrowed arterioles do not permit sufficient blood to pass the sluice gates of the dam to provide adequately all the needs of the tissue cells The early changes are but exaggerations of the normal activities of the arterioles and are intermittent At first this interference causes little or no disturbance and there are no resultant symptoms Later, often only after some years, when the constriction of the regulatory arterioles is continuous, evidence of such circulatory deficiency is to be found But the evidence or symptoms are *not* directly referable to the vessels or to the high blood pressure; they are referable to the inability of certain tissue cells to do their work properly. Thus the symptoms which arise late in the course of the disease (and it can not be over-emphasized that early there are no symptoms) differ greatly in different individuals. The character of the symptoms depends upon the site, extent and abruptness of the local failure in blood distribution In some the brain will suffer from the inefficiency of the circulation, in others the kidneys, the eyes or the heart Thus the symptoms will be as legion in their patterns as are the cases

The requirements of cells for oxygen depend upon how much work they are asked to perform The muscles of the leg, for example, require at least ten times more oxygen when a man is running than when he is standing The deficiency in oxygen supply (or blood supply, for the one depends upon the other) first becomes manifest under conditions of stress or increased activity. All structures in the body have a large reserve capacity to meet unusual demands; depreciation of this reserve is gradual and often almost imperceptible Evidence of failure does not occur until the capacity to work is actually less than the requirements.

Heart failure accounts for from 50 to 60 per cent of deaths attributable to high blood pressure Such failure may be of several forms, abrupt or gradual, but that does not concern us here. Some damage to the heart in high blood pressure is inevitable Heart injury is the gravest risk to the hypertensive Hypertension presents a triple threat attack upon the heart First, the heart muscle suffers when its own supply of blood in the walls of the heart is interfered with by arteriolar disease Second, the heart is the one structure constantly required to carry an increased burden of work, as the resistance to the free flow of blood increases (resistance offered by the narrowed arterioles throughout the body) it must work harder and harder to overcome this Third, the heart is a blood vessel and therefore vulnerable to the same sources of injury as the arteries The factor of increased work under adverse conditions is most significant During rest the normal adult heart moves some ten tons of blood per twenty-four hours This is merely the weight or volume of blood moved and does not take into consideration the resistance to the free movement of the blood Increased resistance may double the amount of work involved Thus the heart is working as though the man were climbing stairs constantly—day and night—and doing this with a collar so tight that it is hard to breathe. It is not surprising that the heart wears out prematurely

The depreciation of the heart's vigor and reserve is at first so gradual and painless that it is usually ignored by the patient. Through centuries of struggle we have come to recognize pain as a warning so much so that automatically and reflexly we cease doing anything if it hurts to continue. But pain is almost the only warning which we heed, with ostrich-like blindness we try to "explain" other forms of distress or warnings as being insignificant, closing our eyes to the implication that following such warnings is our best protection against disaster. The

motor car has brought us the green, amber and red lights. We must learn to heed these warning lights if we wish to survive long in the chaotic traffic of modern existence

What are the "lights" with which the heart cautions us to "go slow" or to "stop"? There are several, but the most frequent and important one is breathlessness. Now, breathlessness on exertion is a perfectly normal phenomenon *if the exertion is sufficiently strenuous!* For the runner, after a hundred-yard dash, to pant is normal because his muscles have used up more oxygen than his lungs, heart and circulation can supply in the ten seconds of violent exertion He has borrowed, created an "oxygen deficit" by extreme expenditure in the intense effort of the race. Not even the normal circulation can supply the oxygen demanded at the moment But the debt must be paid and promptly Therefore the panting, sobbing, deep breathing which follows Here we have one example of the liberal credit structure with which nature endows us. We can "borrow" against the future in many ways ("running on one's nerve," using drug stimulants such as caffeine to carry on despite the warnings of fatigue, burning the fuel of tissues, later to be replaced with food, are other illustrations of biologic borrowing), *but the debt must always be repaid.* Herein nature's laws are sane, no "New Deal" legislation can postpone the day of payment

Breathlessness becomes an amber light, warning us to "proceed with caution" when it appears upon less and less effort It is not the breathlessness or panting which is so significant *but the degree of effort necessary to induce it!* The man on the street, the banker at his desk, the obese matron nibbling chocolates at a matinee, the business man puffing up the hills on the golf course "for business reasons" all attribute their increasing "shortness of wind" to something else than heart depreciation. "Too many cigarettes," "indigestion," "didn't sleep well last night," "worry" or "getting a little soft now" are some of the innumerable soothing syrups with which self-delusion is continued. Let us not criticize; it is human nature to resent the depreciation of the years, particularly if conceit and ambition make us feel important to the world The plaintive rebellion of self-esteem against restraint is: "Slow down? I can't. My business needs me." None of us are *that* important to others; only to ourselves do we appear so Triteness alters not the fundamental truths, and repetition of the ancient axioms that "haste makes waste" or "make haste slowly" falls upon ears deafened by the roar of the city

More can be accomplished leisurely than in haste. The artist knows this So does the true teacher. The grubber for money does not Let us recall that we live but once and must expect to remain dead a very long time Alfred Stieglitz, the artist, once thought of his own epitaph while in the dentist's chair "I have lived for better and for worse, but I am dead for good "

The warning of breathlessness on less and less effort comes gradually Hypertension and heart depreciation do not at once imply immediate jeopardy. Nor do they denote invalidism. High blood pressure is in itself not particularly dangerous. We have tried to explain this Its risks are in the future. The progression of the disease is slow, years elapse before the changes become irrevocable and the danger of disaster is great But for all the slowness of this depreciation, it is inevitable and persistent There is always the potentiality of acceleration of the degenerative process; acute infections, fatigue, continued worry, intoxications of any sort may quicken the rate of depreciation at any time and thus bring closer the ultimate, inevitable failure There is no tendency toward spontaneous improvement or cure Ignoring the existence of

the threat of high blood pressure, while perhaps stupidly reassuring the apprehensions of the patient, accomplishes nothing else.

The objectives of treatment are to prevent, or at least postpone, the future difficulties and disasters of heart failure, apoplexy or kidney failure. An attitude of prevention is essential. High blood pressure is a controllable disorder, but it is not a problem which can be treated for a few weeks and then wholly forgotten. The likelihood of recurrences and flare-ups is an ever-present menace, and observation and guidance must be continued To be precise, we should say hypertension is controllable rather than curable.

It is impossible and inappropriate to attempt to discuss treatment here, but certain aspects of the broad problem warrant mention As *prevention* is the primary objective, *early detection* of the disorder is the first step Failure to start treatment during the early stages of the disorder tremendously increases the difficulties of management later on As previously mentioned, it is when irrevocable damage has occurred that patients expect a miracle The responsibility for health rests first and foremost upon the individual, a physician can accomplish nothing unless the patient cooperates So many take the infantile attitude that in following advice they are doing it for the doctor, forgetting that it is for *their* benefit, not his, that the advice was given This attitude is exceptionally prevalent among hypertensive individuals; they feel well and are often unusually energetic They deeply resent the implication that they are not well This blindness, which is part of the combative personality of hypertension, is a real handicap to the intelligent physician trying to postpone future disasters

The earlier the disorder is detected and management instituted the better are the chances of accomplishing the objectives of prolonging life and health to its normal span As high blood pressure is usually unaccompanied by symptoms which call it to the attention of the victim (at least, not early in the course of the disease) it is necessary to search for it Determination of the blood pressure is a simple safe quick procedure, free of discomfort It is a matter of but a few moments Periodic inventory of one's physical condition is the answer to the problem of early detection of disease and its corollary, successful control It is extraordinary how well we treat our automobiles and how shabbily we treat our bodies We don't hesitate to run in to the service department of the car dealer to "tune the motor" or "check the brakes" or complain of this or that, but how few will trouble to see if their own motor is behaving quite as it should Banks balance their books daily, the merchant takes periodic inventory of his stock, the manufacturer constantly inspects not only his product but his equipment, and yet ignores his most precious investment—his health.

Periodic health inventory should be at least an annual event when all is apparently normal To be of value it must be thorough No public accountant can analyze the books of a year's business in a few minutes, remember that *your* body is a complex "business" Give your physician the opportunity to be thorough in his search for facts upon which to base his decisions and advice That advice may have far-reaching consequences If evidences of illness are found, recheck at much more frequent intervals than twelve months is, of course, in order Such evidences may be more indicative of potential illness than of actual existing disease It is possible now, with the aid of a simple but effective test procedure, to determine potentiality to high blood pressure even before it occurs This is done by observing the response of the

blood pressure to a standard stimulant such as cold Even in children the test has revealed the inherited tendency to be vulnerable to arterial disease; comparison of the results of many tests on school children showed a conspicuous association between such warning responses and the presence of high blood pressure in one or both parents. Thus the patient with high blood pressure owes it to his or her children that they be guarded before it arises in them In matters of health particularly the old adages "forewarned is forearmed" and "an ounce of prevention is worth a pound of cure" are basic, fundamental truths

If the task of devising a suitable motto to be inscribed above the blackboards of schools were assigned to me, I should write "You will not find Truth unless you look for it."

As each instance of the disease presents a different problem from the viewpoint of *cause*, so each instance is an entirely individual problem in *treatment*. Individuality in treatment is essential It is possible only after thorough, painstaking study of the patient, the reasons for his illness, the extent and duration thereof, the status of the heart and kidney reserve capacities and many other factors. The first principle of curative treatment is that it shall include consideration of the causes of an illness To treat a sore heel due to a nail in a shoe accomplishes nothing unless the nail be removed. The second principle is that the injured structures (in this instance, the blood vessels, heart and kidneys particularly) shall have as much rest as possible so that they may do their own repairing with the least hindrance. Time is an essential ingredient of rest Thirdly and lastly, treatment must consider the nutrition of the patient as a whole and of the injured part in particular To illustrate this last principle we may cite the importance of correcting anemia, even of mild grade, in high blood pressure Recalling that the damages done result from the inadequacy of blood flow to the tissue cells, we can at once see how tremendously this detriment is enhanced when the blood which does reach the cells is not up to par and is deficient in oxygen-carrying capacity. The double insult quadruples the injury

Successful control, making possible many years of happy, vigorous and useful life, does not imply making an invalid out of the patient That is almost always unnecessary Temperance in all things, wise counsel, with the intelligent, occasional utilization of certain drugs, constitutes a type of approach which is most often eminently successful An attitude of optimism is fully justified. The earlier recognition of the condition occurs, the better the outlook. The problem is one of treating the patient, not the disease.

GEOLOGICAL STORY OF THE GREAT LAKES

By the late FRANK BURSLEY TAYLOR
U. S. GEOLOGICAL SURVEY, 1900–1916

THE Great Lakes of North America—Lakes Superior, Michigan, Huron, Erie and Ontario—gave to our continent a distinction not enjoyed by any other, for no other has so many lakes of large size so closely connected and so well situated to serve the needs of man While a very notable group of lakes occurs in Africa, only one—Lake Victoria—is of a size comparable to Lake Superior, and the whole group and its surroundings is in other ways very different from ours Our lakes lie in the middle north latitudes, with a vast area of fertile plains stretching away to the south and west, where the soil and the prevailing climatic conditions favor the highest development of agriculture This relation is fortunate for many reasons It has been especially favorable not only for the growth of agriculture, but also for the development of water power and great industries, as is exemplified in several of our most populous and prosperous states. Rich stores of copper and iron lie near Lake Superior's shores and coal and petroleum near Lakes Huron and Erie. Lake Superior is nearly 400 miles long and averages about 90 miles wide It is six hundred feet above the sea, while Lakes Michigan and Huron are twenty feet lower and Lake Erie is eight feet lower than Lake Huron. Lake Ontario is two hundred and forty-five feet above the sea Lake Superior is one thousand feet deep, Lakes Michigan, Huron and Ontario between seven and eight hundred feet, while at its deepest spot Lake Erie is only a little more than two hundred feet deep

The connecting rivers between the Great Lakes have all been made navigable and, with the lakes themselves, now constitute one of the greatest highways of commerce in the world. Ultimately, the whole group will be effectively connected with the Gulf of St. Lawrence and with the Hudson River and, through the Mississippi River, with the Gulf of Mexico Fishing is a great industry on the lakes and yields a large supply of some of the finest food fishes known The shores of the lakes are dotted with summer resorts, where each year thousands of people find relief in the heated season

Thus, briefly, we may describe the Great Lakes as one sees them to-day But to an inquiring mind, certain momentous questions press for answer, especially questions relating to the origin and history of the great rock-hewn valleys in which the lakes lie. How were they formed and why were they placed where we find them in the broad expanse of the continental plain? The answers to these and to many other questions are to be found chiefly in the geological history of the lake region and of the continent itself

The accompanying map of North America, Fig 1, shows that the Great Lakes lie in the east central part of the continent, where, excepting for the Adirondacks and the relatively low ranges of the Appalachian Mountains on the south, the whole vast area reaching from the Arctic Ocean to the Atlantic and the Gulf of Mexico is essentially a plain country that seldom rises more than one thousand feet above the sea The region of the Great Lakes is a relatively quiet part of the continent, there is no evidence that it has had a turbulent history,

at least not since the beginning of the Paleozoic Era or time of ancient life, some 550 millions of years ago The lake region, so far as known, has been visited by few earthquakes of importance, such as have been observed were relatively mild and rarely destructive It has had no active volcanoes since the lake basins began to be made.

The Canadian Shield

The beginnings of the geological history of the Great Lakes are intimately bound up with the early development of the continent itself, and the continent has had a very complicated history, the early chapters of which are naturally more and more obscure as one goes farther back in time

One of the most remarkable features of the North American continent is the so-called "Canadian Shield"—the great flat plain or low plateau which surrounds Hudson Bay, so named from a fancied resemblance to an inverted shield. It is for the most part a veritable rocky wilderness and extends a thousand miles to the east and to the northwest from the shores of the bay and more than half that distance toward the south and southwest On a good geological map, especially if printed in colors, the shield stands out conspicuously, its gross area, including that of Hudson Bay and most of the Arctic Archipelago, amounting to something like one fourth of the whole continental surface. Two other shields of the same kind occur in high northern latitudes, the Baltic shield in northern Europe and the Angara shield in northern Asia, and it is a notable fact that they all have the same general characteristics.

The origin of the shields is one of the most obscure problems of geology, but whatever its origin, the Canadian shield stands in a peculiar and very significant relation to the Great Lakes. In Fig. 1, the southern boundary of the shield is shown as extending from the Strait of Belle Isle southwestward along the north side of the Gulf of St. Lawrence, up the St. Lawrence River to the vicinity of Montreal, thence westward along the north side of Georgian Bay and across Lake Superior to a point near the center of its north-west side Here the boundary turns toward the northwest and passes through or near to Lake of the Woods, Lakes Winnipeg, Reindeer, Athabaska, Great Slave and Great Bear to a point on the shore of the Arctic Ocean about one hundred miles east of the mouth of Mackenzie River. Thus, on the southeast the boundary is marked by marine waters in the Gulf of St. Lawrence and on the south and west by a chain of lakes extending from Lake Ontario to the Arctic Ocean. In the north the boundary is not sharply marked, but in a rough way may be considered as passing northeast across the Arctic Archipelago and thence southeast to the Strait of Belle Isle. Some geologists include nearly the whole of Greenland in the Canadian shield, where, in all probability, it really belongs

It seems certain that some sort of causal relationship exists between these features; but the complexities of ancient geological history have made it extremely obscure It is worthy of note, however, that in Europe the southern boundary of the Baltic shield is marked in the same way by lakes and marine basins Lakes Ladoga and Onega in Russia, with two or three basins in the White Sea and, on the west, the Gulf of Finland, the Gulf of Riga and probably a part of the Baltic Sea itself mark the boundary. In northern Asia, Lake Baikal may perhaps be related in this way to the Angara shield, but the relationship is not certain and no other lakes or marine basins so related are now known.

The surface of the Canadian shield is, in reality, a vast rock floor which, despite

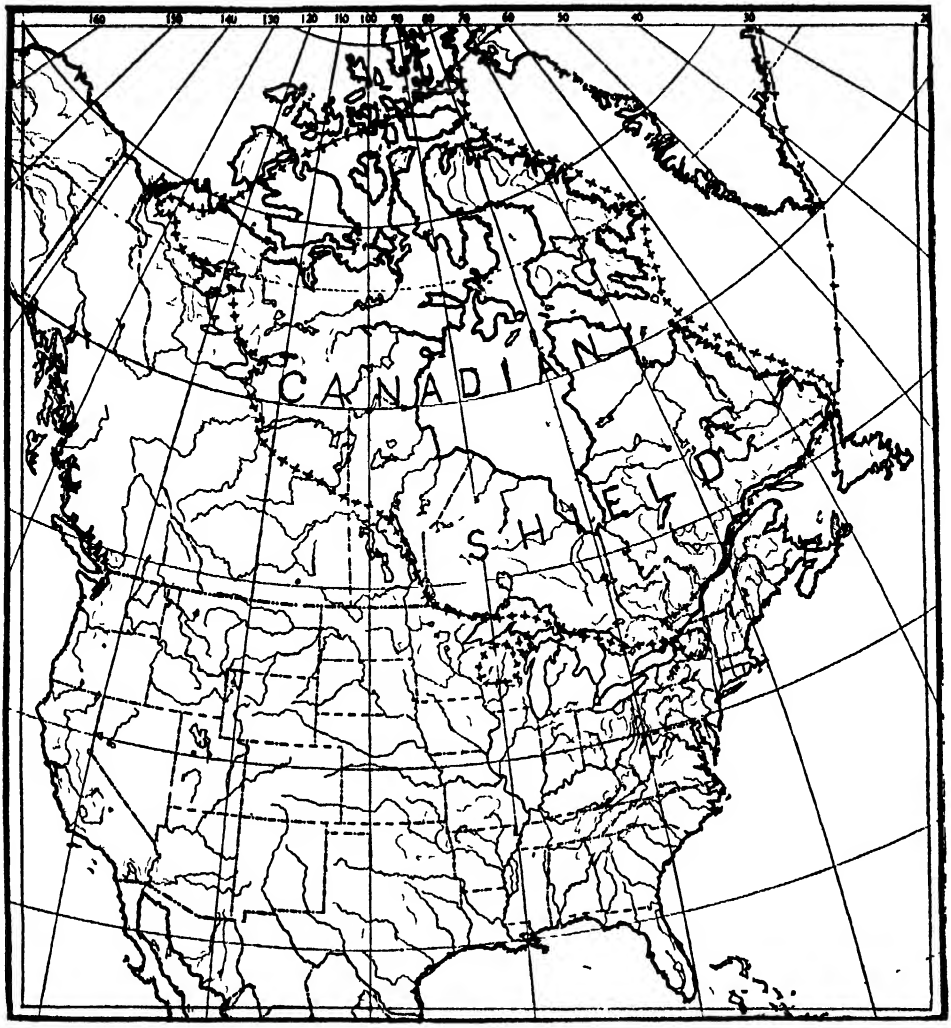


FIG 1. PART OF NORTH AMERICA

SHOWING THE LOCATION AND EXTENT OF THE CANADIAN SHIELD AND THE RELATION OF ITS BOUNDARY TO THE GREAT LAKES AND TO THE LAKES OF NORTHWESTERN CANADA. (AFTER SCHUCHERT)

the vicissitudes of a varied history, appears to have kept its identity for hundreds of millions of years But great as is the area of the shield floor now visible, this is by no means its whole extent, for there is evidence that it runs for undetermined distances toward the south and west under all the rocks of later age. In fact, it has been identified in deep borings at a number of places.

Alternative Views of the Probable Origin of the Lake Valleys

Studies of geological structure in the region of the Great Lakes made with special reference to their bearing on the way in which the lake valleys were shaped have resulted in a general agreement on certain points. First, the lake valleys were not made outright by a supposed gouging action of the ice in the ice sheets

of the Glacial or Pleistocene period, as has sometimes been suggested; nor, with the possible exception of a part of the basin of Lake Superior, are they to be considered as original rock-basins due to great hollows or troughs shaped directly by the folding and downward bending of the rocky strata, nor are they due to any form of marine action which would necessarily be limited to the work of waves and currents, but on the basis of many clearly defined evidences it seems certain that they are due almost entirely to subaerial erosion—to wind and rain and to rivers and smaller streams, like those we see to-day But the magnitude of the lake valleys is so great that the idea that they were made by the agencies of ordinary subaerial erosion seems hard to believe, and becomes acceptable only when we give the streams an enormous allowance of time, at least tens of millions of years, for doing their work. But since the discovery of radio-activity in some of the most ancient rocks, a new and wonderful method of measuring geological time has been discovered and its adoption provides more liberally for the slow processes of nature.

The Building of the Paleozoic Sediments

In striving to visualize the main events which prepared the way for the making of the Great Lake valleys, it is to be remembered that, excepting probably part of Lake Superior, all the lake valleys have been carved out of the great mass of the Paleozoic rocks and that these rocks were evidently deposited in the ocean, for they contain the fossil remains of many kinds of marine animals. It is certain that the whole region where these rocks are now found was submerged under the sea for practically all the Paleozoic Era, estimated to have endured nearly 360 millions of years and ending about 190 millions of years ago

But the attitude of the rocky strata has been greatly changed since that time, for from central New York to the south side of Lake Superior, the whole mass now dips moderately downward toward the south so that wherever their edges are exposed they are seen to project upward toward the north, as though they had formerly extended much farther in that direction It seems certain that the Canadian shield or a considerable marginal part of it was submerged under the sea during all or nearly all of Paleozoic time, otherwise, it could not have received upon its surface so great a mass of marine sediments The structure of the deposits shows that they came from a source toward the southeast or south and were spread toward the north over the nearer parts of the shield. Under these conditions, the slope of the beds as they were being deposited would naturally be toward the north, but would be very gentle for the finer sediments Beginning at the bottom with very ancient sandstones and conglomerates (Cambrian), the Paleozoic deposits comprise, in their total depth, an enormous mass many thousands of feet thick, and including the sediments of all the six or seven periods which make up the Paleozoic Era, ending at the top with the coal-bearing beds of the Carboniferous and Permian periods At places near the lake basins and especially near the southern boundary of the shield, the thickness of the deposits was less, because all the beds grew thinner toward the north On the shield north of the lake region, their thickness was probably still further reduced. Then, too, practically all the coarser sediments had been deposited farther south and only the finer grades, like clay and silt, were carried for a notable distance out over the shield. Until the building of the Paleozoic rocks was finished, they appear to have rested quietly in the sea and to have suffered no

notable disturbance, at least in the area comprising the lakes.

The Erosion of the Great Lake Valleys

At length, toward the close of the Carboniferous period, a great change began, the exact nature of which is not surely known, but as a result the Paleozoic mass gradually became dry land. Two ways of explaining such a change have been considered by geologists: either the earth's crust was broadly uplifted over a wide area, thus raising the Paleozoic mass to a considerable height out of the sea and turning it into dry land, or, the solid earth remaining substantially undisturbed, the ocean waters gradually fell away to a low level, leaving the Paleozoic mass high and dry. Possibly both kinds of change were involved, but whatever its nature, the change probably came about slowly, not suddenly

When the surface of the new land appeared above the sea, it was attacked immediately by all the forces of subaerial erosion—wind, rain, rivers and their smaller tributary streams and by the waves and currents of the sea along its shores A drainage system with a central master stream flowing along the valley axis was soon developed on the site of each lake valley In the valley of Lake Superior the master stream flowed toward the east, in Lake Michigan, toward the north, in Lakes Erie and Ontario, toward the northeast and east In Lake Huron the course of the master stream was probably toward the north at first, but later may have been toward the south A separate stream drained the valley of Georgian Bay, at first probably toward the north, but later toward the southeast At first, all these streams probably flowed out onto the surface of the shield

Early in their work the streams discovered the lines of the weaker rocks and in these they worked more rapidly. Thus, the weaker rocks determined the place and axial direction of the valleys and as erosion approached maturity, the influence of the softer rocks became more and more pronounced At first, no outlets were found toward the west or south, but toward the east barriers of weak rocks separated one valley from another, as between Lakes Michigan and Huron, between Lakes Huron and Erie, and between Georgian Bay and Lake Ontario With these barriers cut through, the main streams were united into a more compact system and were enabled to erode the valleys to their deepest parts Because of the great duration of the period of erosion, the streams were enabled to widen their valleys extensively and by this means to bring them to their present shapes and arrangement

The reason for the existence of Niagara Falls is the presence of the massive and relatively hard layer of the Lockport limestone or dolomite, with a great depth of soft rocks below it. More soft rocks, but not so thick, lie above it The Lockport hard layer fades away eastward in New York, but it extends westward into Canada and, after turning around the west end of Lake Ontario, forms a bold escarpment extending northwest to the Saugeen peninsula, which separates Lake Huron from Georgian Bay Beyond that it extends through Manitoulin, Cockburn and Drummond Islands, then through a range of hills a few miles north of the Straits of Mackinac and finally reappears in the Garden peninsula, Washington Island and the Door peninsula, which separates Green Bay from Lake Michigan. Thus, the valleys of Green Bay, the North Channel, Georgian Bay and Lake Ontario were excavated out of the soft rocks *below* the Lockport hard layer, while Lakes Michigan, Huron and Erie were excavated out of the soft rocks *above* that layer. Thus we see that after the greater things, like the existence of the continent itself and

the Paleozoic sediments, the most important factors in locating and shaping the valleys of the Great Lakes were the existence and arrangement of hard and soft rock-layers in the lake region and the peculiar selective action by which the forces of subaerial erosion made the valleys in the soft layers and left the hard layers almost untouched.

Turning the Dry Valleys into Lakes

The lake valleys were now completed, but there were no lakes; the valleys were still drained by the streams that made them The transformation, however, was simple, for the Canadian shield, or a broad marginal part of it along the south and west sides, began to be slowly uplifted after the manner of a wide swell This affected the land all along the boundary of the shield, the parts inside more than those outside, so as to produce a marked tilting downward away from the shield. Thus, the northern parts of all the valleys, with most of their outlets, were raised more than their southern parts, forming basins in which the waters gathered to form lakes

The disturbances caused by the making of the Appalachian Mountains probably raised the Paleozoic sediments out of the sea and started the erosion of the lake valleys This erosion, as we have seen, must have required a very long stretch of time, falling, perhaps, partly during the making of the Appalachians, but mainly during the long period of the Mesozoic Era or age of reptiles which followed. Certain it is that the whole of the lake region was continuously a land surface subject to subaerial erosion during the entire time of this era The Mesozoic Era followed next after the Paleozoic, beginning about 190 millions of years ago and ending about 65 millions of years ago. It was, apparently, in the middle or latter part of the Mesozoic that the very slow tilting of the land in the lake region began to affect the newly finished lake valleys and turn them into lakes. Following the Mesozoic, came another era, the Cenozoic, time of modern life or age of mammals, comprising four or five Tertiary periods during which it seems certain that the tilting of the lake basins continued at the same slow rate. During all the Cenozoic also the lake region was a land surface and, excepting effects of erosion which are now largely buried under glacial drift, reveal no notable record of change.

The Pleistocene Ice Sheets and their Effects on the Great Lakes

With the opening of the Glacial or Pleistocene period, about one million years ago, came a new phase of the lake history A series of continental ice sheets advanced from the north and northeast over the Great Lakes region, and while they did not make any of the lake valleys outright, they modified some of them considerably, but rather more by the deposition of drift in their basins than by glacial abrasion

The cause of ice sheets is not definitely known, but many suggestions have been made. One that is now held in some favor finds the cause in a long-period variation in the quantity and intensity of solar radiation. At any rate, through several thousands of years the winter snows that fell on the higher ground surrounding Hudson Bay failed to melt in the following summers and, accumulating from year to year at a slowly increasing rate, finally produced a vast field of snow and ice—the beginning of an ice sheet. In forty or fifty thousand years, the ice on the Labrador peninsula, where it appeared to begin to grow, attained at its maximum a thickness of a mile or a mile and a half The ice literally *flowed* away from the central area under the urge of its own gravity, but of course with extremely slow motion, much slower even than that of pitch or asphaltum in cold weather. It spread out over the whole of New England and the Great Lakes

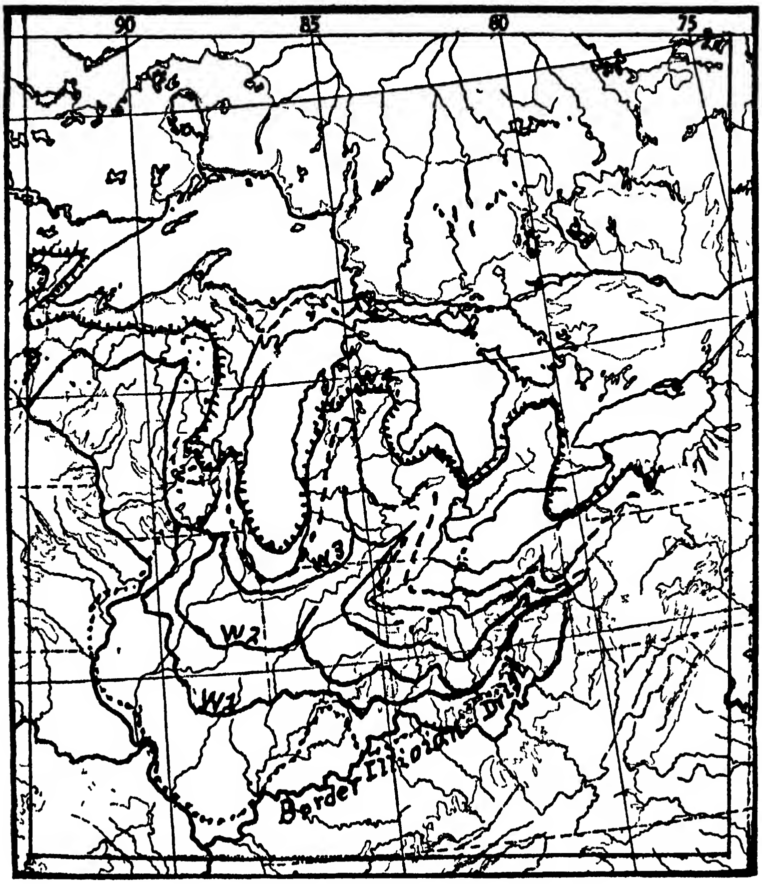


FIG 2. REGION OF THE GREAT LAKES

SHOWING BOUNDARY OF THE ILLINOIAN DRIFT AND SEVERAL RECESSIONAL MORAINES OF THE WISCONSIN DRIFT MORAINES MARKED W1, W2, ETC, WERE BUILT AFTER MORE IMPORTANT READVANCES THAN THE AVERAGE TWO ADDITIONAL MORAINES INSERTED BETWEEN W3 AND W4 ARE SHOWN IN OHIO SOUTHWEST OF LAKE ERIE IN ORDER TO EMPHASIZE THE CLOSE RELATION OF THE ICE FRONT TO THE BASIN OF LAKE ERIE. ONLY A FEW OF THE RECESSIONAL MORAINES ARE SHOWN. (MAINLY AFTER LEVERETT.)

region. It moved over the tops of hills and even of mountains of notable height, but in order to do this by its own weight its surface had to have at least a gentle downward slope from its center of accumulation. Its semi-plastic movement enabled it to fit itself to the features of the land with perfect fidelity. Each lake valley became the site of a great lobe of the ice sheet and the high lands between the valleys became the heads of re-entrant angles giving to the front temporarily a scalloped pattern, like that shown in Fig. 2

Four or five separate ice sheets swept over the lake region—the Jerseyan, Kansan, Illinoian, Iowan (?) and the Wisconsin. All covered nearly the same area, so that only relatively small parts of the earlier sheets have remained uncovered. Long warm periods intervened between the successive ice sheets; a wonderful record of one of them was found at Toronto showing leaves of warm-climate trees in

an interglacial bed. We learn how the ice sheets behaved in the lake region mainly from a study of the composition and distribution of the Wisconsin drift, because it covers practically the entire surface

At its maximum, the front of the Wisconsin ice sheet rested on the Hartwell moraine ten miles north of Cincinnati When the ice front began to retreat, it moved in an oscillating manner, as if by two steps backward, then a halt; one step forward, then a halt, and so on, oscillating all the way back to the northern highlands The ice sheet built a marginal moraine at every halt, but all those built at backhalts were later overridden and destroyed by the next readvance, while all those built at forward halts remain as a beautiful record of the ice's oscillating retreat These recessional moraines reveal intimately the relation of the ice sheet to the lake basins and to the land in general From near Cincinnati to Lake Ontario there is a perfect series of twenty-seven of these moraines. Allowing a time for retreat, readvance and halt, which seems appropriate to the slow movements of ice sheets, it seems probable that each complete oscillation took one thousand to eleven hundred years, making the time of retreat to Lake Ontario nearly thirty thousand years Then a few thousand more must be allowed for the retreat farther toward the north, so that forty to fifty thousand years would seem to be an approximate measure for the retreat from Cincinnati How much more time has passed since then we do not know, except as Niagara Falls helps toward an estimate It is believed that it has been eighteen to twenty thousand years since Niagara Falls began making the gorge at Lewiston This seems a fair measure of the time taken for the ice to retreat from the south side of Lake Ontario to the northern highlands and probably includes also the time that has passed since the last of the ice sheet melted.

It seems certain that at the beginning of the Ice Age, the main rivers had cut deep channels between some of the lake basins Borings indicate such a channel extending from Georgian Bay to Lake Ontario near Toronto. Another probably extends from Lake Huron to Lake Erie, and one may also have extended from Lake Superior to Lake Huron No continuous deep channel is known extending from Lake Erie to Lake Ontario, but a boring at Euclid, a suburb of Cleveland, went nearly to sea level without meeting bedrock, showing that the rock basin of Lake Erie probably reaches sea level or lower, but owing to a heavy filling of drift, its greatest present depth is only a trifle more than two hundred feet If the drift fillings were all removed some of the lakes would stand at much lower levels than now, and the lakes in general would present a very different appearance from those we see to-day The valleys of the Great Lakes are very old, as water-filled basins, they are considerably younger; but as basins smoothed and slightly remodeled by the gentle touch of the ice sheets, they are relatively new.

THE SOUTHEASTERN CHINANTLA OF MEXICO

By Dr. J. STEWARD LINCOLN

A YEAR or two ago I fortunately had an opportunity to visit and make ethnological studies in the State of Oaxaca, a little-studied region of Mexico lying immediately west of the State of Vera Cruz

The Chinantec villages visited were Lalana, Lachixola, Jocotepec, Rio Chiquito, San Jose Rio Manzo, Tepinapa, Toabela and Lovani, all situated in the State of Oaxaca, in a territory which stretches from the northeastern slopes of the Sierras to the borders of the State of Vera Cruz, an area of approximately 2,000 square miles shown in the accompanying sketch map (p 58)

The Sierras cut off and isolate this tropical section of the Chinantla,[1] climatically designated as "*caliente humedo,*" from the Zapotec and Mixe regions, and communications over the mountains from the Southwest are through steep and difficult trails

There appears to be a distinct Chinantec physical type as definite and outstanding as any in Oaxaca The individuals of this type are medium in height, with black, straight hair, and pale, coffee-colored skin, with oblique slanting eyes and round heads, although there are numerous other physical types mixed up with the former This difference in physical type may be caused by the custom, which is reputed to prevail, of inviting foreigners and visitors to have children by their women If this is the true situation the stock can in no way be regarded as pure

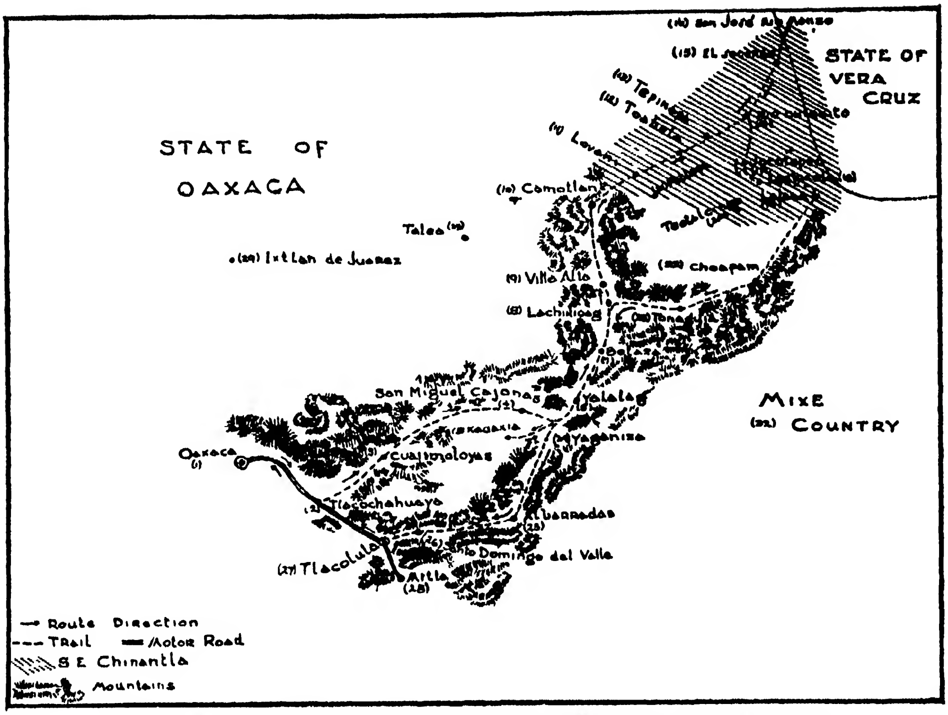
Throughout this section the women are good-looking, hard-working and prolific They are shy, extremely reserved and inclined to hide and run away at the approach of visitors The married women are distinguished from the unmarried by wearing their hair parted in the middle, twisted and coiled coronet fashion, with fan-shaped puffs over the ears The unmarried girls keep theirs in braids, which are lengthened by twisting with strands of wool When bathing, which always takes place in the open under a primitive shower bath, made by placing a bamboo trough in the steep part of a running stream, generally near the village, the married women sit down, but the unmarried girls stand The married women wear a red cotton skirt, over which is worn a white *huipil* The unmarried girls wear only the *huipil*

Temperamentally, the people whom we encountered were gentle and reserved, but very soon become hospitable and generous hosts Food was always forthcoming, and often no payment was requested in spite of evident poverty This non-aggressive,[2] friendly and shy, temperament is quite in contrast to the unfriendly, sullen or aggressive attitude of the neighboring Zapotec men in the villages of Lachirioag, and Yalalag on the West of the Sierras, and the loud-mouthed, cackling and even brazen Zapotec women The latter, however, have a keen sense of humor and are easily aroused to paroxysms of loud and side-splitting laughter

In all the villages visited, both the men and women are hard-working, and have a well-organized, integrated town life.

[1] For description of fauna and flora, see Cayetano Esteva, "Nociones Elementales de Geografia Historica del Estado de Oaxaca," Oaxaca, 1913.

[2] It appears that in the first written historical record in which the Chinantecs were mentioned they were a war-like people and good fighters. Bernal Diaz del Castillo, "The Discovery and Conquest of Mexico." Broadway Travellers, 1933, pp 373–74; 397.



OAXACA SHOWING RANGE OF SOUTHEASTERN CHINANTLA

They are exclusively an agricultural people, and raise chiefly coffee, bananas, corn, sugar cane, tobacco and chiles. These products are raised almost entirely for home consumption, although a small amount of their excellent coffee is exported. One man in Jocotepec explained that he would like to export more coffee, but the difficulty of getting it to the railroad by human carrier made it too costly. Pigs, turkeys and chickens are raised. The men work in field and plantation, and the women do household work, cooking, drawing water and gathering wood, husking and grinding corn, making *tortillas* and looking after the family and domesticated animals.

Contrary to expectations, alcoholism seemed to be lacking as an every-day situation in all the eight Chinantec villages to which we traveled No *fiestas* took place during a three weeks' visit; hence it was impossible to estimate the amount of drunkenness at these times. Probably it would have been most evident at *fiestas,* as in all parts of Mexico. Not one case of drunkenness was noticed, however, although one informant requested that he be paid in alcohol instead of money. The request was refused, but it did not make any difference in his disposition or his willingness to work This situation is quite the opposite to that found in the high Yolox and Valle Nacional sections of the Chinantla where chronic drunkenness is the order of the day irrespective of *fiestas,* according to the report of a member of a scientific expedition to that region [3]

The whole question of the effect of alcohol on the Indian organism and temperament is a field for the trained medical psychiatrist, and it would be worth while to pursue the study of alcoholism in relation to contact with advancing civilization Whether chronic drunken-

[3] A member of Mr Bernard Bevan's expedition.

ness among Mexican Indian groups is due entirely to inferiority feelings because of sudden contact with a new and crushing civilization, as suggested by Tannenbaum, is still open to question as a sole explanation. It would not explain why certain Zapotec and Mixe villages in the high Sierras, remote from the new order, are often encountered in which a state of chronic drunkenness exists, whereas the equally remote southeastern Chinantec villages do not suffer from this social disease. Constitutional, temperamental and social factors must here be considered in all their interrelations.

In the case of the southeastern Chinantecan villages, the remoteness is emphasized by the lack of roads, railroads or other modern means of communication with the outside world. The social plans of the revolution have barely begun to simmer through to these people. Of the eight villages visited, only two had schools and school masters. As a result there is a complete absence of medical or hygienic knowledge, and *curanderas,* who are often regarded as witches, are still consulted for cures of illness. Nevertheless, observation shows that personal cleanliness and numerous baths in the open are usual. Clothes, however, are apt to be shabby, ill-kempt or dirty, but the latter is partially compensated for by bodily cleanliness. In connection with personal hygiene, the Zapotec town of Yalalag presents a complete contrast from the villages of the southeastern Chinantla. Outwardly this town is clean and the two-story houses are newly painted in white. All the inhabitants are clothed in pure white cotton, the women in embroidered, hand-woven, clean-laundered *huipils.* Washing of clothes is constantly in evidence. On the other hand, the abounding filth and lack of sanitary arrangements make this town a peculiarly unhygienic one, especially called to attention in relation to the clean white clothes. The situation seems to be a combination of extreme cleanliness of clothes, with bodily uncleanliness.

Kinship terminology recorded in five villages now follows the Spanish family system, as in many parts of Mexico, with some terms expressed in Spanish, with no equivalent in native language.[4]

LACHIXOLA (SAN MIGUEL)

It is interesting that a Chinantec calendar still in use should have been discovered in this village, which, from the reports of two informants, is probably not an ancient one.[5] The population now consists of about 70 individuals, which comprises 17 taxpayers and their families. About 30 years ago the population was almost wiped out by a smallpox epidemic. In a census of 1883 the population was given as 140, and in one of 1891, as 160.[6] There are two old men surviving the time of the epidemic, who still live in the village. During the epidemic, they remained outside of town on their *milpas*. The informants, Jose Arcienega and Francisco Feria, spoke practically no Spanish, and had as interpreter, the *Secretario,* Pedro Perez. Jose was a small child during the smallpox epidemic, and both his father and grandfather died then. The families of both informants have been in the village for several generations, exactly how long they did not know. They said that the tradition was that the village was founded as a *Rancho* by people from Teotalcingo, as a place to stop on the way from Monte Negro, a nearby trading center. A few stayed behind to plant and told others about it, and gradually developed the village of Lachixola. The date when this occurred is unknown. There is no memory of any important outstanding or

[4] J. S. Lincoln, "Zapotec, Chinantec and Mixe Kinship Terms in 1936." (Unpublished.)

[5] I. Weitlaner, "A Chinantec Calendar." *American Anthropologist,* Vol. 38, 1936, ap. June. Pp 197–201.

[6] "Cuadros Sinopticos de Oaxaca," and an untitled census now in a church in Oaxaca.

venerated individual in the history of the town, according to Jose. There are two bronze bells hanging outside the church, one dated 1777, and the larger one dated 1740, with the inscription "Año Sphe" These were reputed to have been made in the village, possibly by a man from the city of Oaxaca.

Community and political organization follows a pattern found in small villages throughout Mexico A town crier or *topil* calls for volunteers for public works, known as *tequio*. The latter may include building a hammock bridge or a new schoolhouse, or harvesting in the *milpas*, or whatever type of work is required for the community The volunteers receive no pay Lachixola has an *Agencia Municipal* under the *Municipio* of Lalana, a fairly large town about 15 miles away There is one *Secretario*, one *Agente*, one *Regidor* and two *Topiles* (community errand boys) The first three act as judge, legislature and police, and have complete authority in the village. Any major crime is taken to Choapam, where there is a judge Economic disputes and minor issues are taken to the *Alcaide* at Lalana The judge in Choapam delegates his power to the *Presidente Municipal* in Lalana to marry people Generally, people from Lachixola who want to get married must go to Lalana to the *Presidente* Drunkenness is punished by putting the offender into the local jail in Lachixola They are made to work under the authority of the *Agente* as a punishment.

Men leave town every day to work on their milpas,[7] or other fields Coffee, maize, oranges and bananas are chiefly raised. Handicrafts are very weakly developed They make coiled woven baskets and woven nets, but not as a business. There is no weaving of cloth and no pottery is made Cotton cloth is imported from over the mountains, where it is woven by non-Chinantec people, and it is sewed together in the village for clothing Houses are oblong, with roofs pointed and thatched with *rabo de bobo* and *zacate*[8] leaves; walls are of flattened, upright, thick boards and poles of *jonote* wood The thatch and poles are bound with *bejuco* vines. There are doors to the entrances and openings for windows.

In Lachixola young people decide among themselves when they want to marry and when the decision is made, the man gets his father to ask the woman's family for permission to marry The same custom also prevails in Lovani.[9] The groom's father must pay the bride's family from 12 to 15 pesos If the young man goes to work in his wife's family, he does not have to pay He pays only when she goes to live with his family. In Lovani, if the couple go to live with the groom's family, payment must be made to the father of the girl In this village, if the groom or his family are unable to pay for the bride, the groom must work for a year in his father-in-law's house before he is free to return to live with his own family

In Lachixola, the *Secretario* can sometimes get permission from the *Presidente* of Lalana to marry the young couple in the village In some villages, a man can have two wives, but not here, and, of course, sometimes they marry into other villages At the marriage there must be four official witnesses, two for the girl and two for the boy The witnesses are given *aguardiente* to drink, but are not invited to the wedding party. The in-laws of the man go to fetch the bride, and all members of both families eat and feast together In these days of few priests, whenever there is a *fiesta* in a nearby village, couples go there and get married by a priest. Lachixola is so poor that it can not afford a priest for its

[7] The word "milpa" is applied only to corn fields.

[8] Corn stalks.

[9] Informant—Don Remigio Martinez at Lovani.

fiesta of San Miguel on September 29. The girls do not wear the red skirt or *chiapaneco* until they are married. For the wedding, the bride wears a new *huipil,* slightly embroidered on the seams with colored thread The groom gives the bride her clothes, and he wears a new white shirt and trousers. Boys and girls marry between 15 and 20. They marry "when they know how to work." In Lovani, girls marry between 13 and 16, and sometimes as early as 12 A girl of 18 in this village, who is not married, is regarded as having missed her chance After the wedding ceremony in Lovani, the bride stays behind the door, while the groom goes all over town with the music and groups of men and women singing

At the *fiesta* of San Miguel at Lachixola, there is no dancing A band comes from Lalana and a *Maestro de Capilla* is sent for who knows how to intone prayers There are no *puestas* or fair booths Everybody wears clean clothes. Formerly they had the *chirimia* or flute playing for all ceremonial occasions, but they no longer have it The player was changed every year, but now no one wants to learn to play In the church, they have *rosario* service only when the *Maestro de Capilla* comes at the *fiesta* of San Miguel in September and for the *fiesta* of San Sebastian in January This situation is different from the custom in Jocotepec, and other Chinantec and Zapotec villages, where *rosario* is held every morning before dawn without any priest At the Mixe village of Tonaguia, *rosario* is also held every day before dawn It seems that in the latter village, it is so long since a priest has been present they no longer remember the words of the responses Attendants at the service intone responsively decidedly non-sacred phrases, many of which end with, "Viva Mexico!"

When people get ill in Lachixola, they buy medicine in the shop at Lalana If seriously ill, they get a *curandera* from Jocotepec or one from Lalana Recently the one from Jocotepec died As mentioned before, there is no knowledge of hygiene in the southeastern Chinantla. At the birth of a child any woman may act as midwife There were several cases of *pinto* in Tepinapa and in Lachixola, a disease whose chief symptom is the loss of pigmentation of the skin in patches which show on the hands, feet and face. Medical opinion regards this as a venereal disease, but differs as to whether it is contagious or not It was noticeable that only one member of a family ever seemed to have this disease, in spite of living in crowded quarters, with wife, children and grandchildren

In this same village, when a man dies, he is put in a sheet or straw *petate,* and he is buried in a cemetery outside of town No money offerings are made The house where the man died is left empty, with the door shut until the man is buried After the burial, prayers are said for three nights for the family of the deceased in the house where he died. A wooden cross is placed on the grave.

In Lovani,[10] when a man dies, all his belongings are buried with him. Food, water and money are also buried to help him on his journey to the spirit world The house where he died is often abandoned Adults are buried with their heads to the west, and children with their heads to the east

At San Jose Rio Manzo,[11] during a burial, the door of the house where the person died must be left open with somebody in the house, and a cross of lime is placed in front of the door inside Prayers are held for nine nights. If the door of the house were not left open, all the people of the house would die.

[10] Informant—Don Remigio Martinez of Lovani

[11] Informant—Magdalena Contreras, the *curandera*

According to one informant, the customs at Lachixola have not changed When there was a *Maestro de Capilla* settled in the village, they used to pray more, but he died in the smallpox epidemic. Nobody in the village has been vaccinated since the epidemic. The *Secretario* makes out death certificates.

They believe that dreams mean something is going to happen. If a person is going to hurt himself by a fall, or if he is going to be bitten by a snake, he will frequently dream about it first. I told Jose that I dreamed that an eagle flew out of an egg. He said that maybe the reason for my dream was because long, long ago, there used to be an eagle which carried people away.

A delightful tale was told by a young Spanish boy who had been brought up from childhood in the Chinantla and could speak Chinantec fluently He accompanied the expedition for a week as interpreter [12] The tale was told to his step-brother's father-in-law by a man from Playa Vicente, and goes as follows

A man from Playa Vicente had lost everything in the revolution and was feeling very downcast, when his *compadre*, an old Chinantec, said to him, "I will cure your trouble" The *compadre* took him up the *Arroyo* Jocotepec, and said that he must not proceed any further, but the man was afraid to be left alone and insisted on going along too They came to a place where there was a lot of *sacate* grass growing They went through the *sacate* and came to the opening of a cave, which was hidden behind the tall growth. The old Chinantec would not let the other man enter, but went in himself and after some time, emerged with a very small *metate* made of pure gold, which he gave to his waiting friend. The old man forbade him ever to tell. The man from Playa Vicente took the golden *metate* and sold it for 250 *pesos*. The old Chinantec died, and the man who had been forbidden to tell of the secret cave, told the whole story to our interpreter's step brother's father-in-law, who set out with the man to look for the cave It rained and rained, however, so hard that they could not find the cave, and they both thought that the rain had been sent to keep them from finding it.

Later, an old Zapotec told our interpreter about the same cave in Arroyo Jocotepec. A young man had heard of it and went there through the *sacate*, tapping with his *machete* on the side of the mountain, and poking through the *sacate* until he had found a hollow place, which was the opening of the cave. He went in, and after he had gone in a long way, he came to a stream which he crossed, and a beautiful girl appeared, who said to him: "There is a lot of treasure in this cave and if you carry me across the stream and get me out of here, the treasure will be yours, only you must not be frightened if I change into a snake as you cross the stream."

The young man took her on his back and carried her and as they came to the middle of the stream, she changed into a snake. He became frightened and threw her into the stream The snake went back to the side from which they had come and changed into a girl again She said, "How foolish you are. If you had taken me to the other side, I would have become a girl again and the spell would have been broken, and you could have married me and had all the treasure."

The old Zapotec said that the same thing had happened to several other young men at one time or another, but to only one that he knew

In Lachixola we found no witches or *Nahuales* and no witchcraft stories were forthcoming. The existence of such a thing was vigorously denied. A longer visit might, nevertheless, uncover such practices and beliefs as found in adjacent villages. In the town of Jocotepec, Lachixola was reputed to be teeming with witches, and in the latter they said that there were many witches in Jocotepec. In Lalana, however, the parent town of Lachixola, there was much talk of *Nahuales* and *brujeria*, and the following tales were collected These are all cast in a rigorous pattern that is found in *nahual* and many *tona*, or animal double stories throughout Mexico, and in the literature.[13]

Nahual stories told at Lalana by Maria Sanchez, whose brother-in-law was reputed to be a *nahual*, June 3, 1936:

A man called Guadalupe Martinez found that one of his pigs had been killed by a tiger. He

[12] Juan Ramon Trinker.

[13] Bibliography of Nagualism in the Paul Vandervelde Library in Oaxaca.

knew that probably the tiger would return the next evening about the same time. He therefore decided to lie and wait for it, and he had his friend have a flashlight ready while he held the shotgun. When they heard a sound where the pigs were, the friend flashed a light and the tiger leaped over the wall of the pig pen. Guadalupe shot, but the tiger ran away. However the flashlight showed traces of blood so that he knew the tiger was hit. He set his dogs on the trail and he and his friend followed. The trail led to the house of Jose Cardozo who was generally suspected of being a *nahual.*

When they arrived at the latter's house, they saw the door of the house just being closed. They knocked and called, but it was a few minutes before they were admitted and they found Jose Cardozo in bed, apparently in great pain They asked his wife what the matter was and she said he had been feeling badly since morning Yet he died that night

When Guadalupe shot the tiger, he saw that he wounded it in the shoulder, but it managed to jump the fence anyhow At Jose Cardozo's house, they saw that he was clutching his shoulder under the covers, but his wife said he had a pain in his stomach [14]

Two old women in Lalana, who were both *Nahuales,* had a violent quarrel, and after the quarrel, a fox would keep coming and killing the chickens of one of the old women The fox did not eat the chickens, but merely killed them The owner realized that the fox was the other woman, her enemy She made a strong solution of hot chili pepper and lay in wait for the fox That night, as the fox ran out of the chicken coop, she threw the solution in its eyes From that day on, the other woman, her enemy, whose eyesight had been good, was blind and she never left her house again even to go to church. Formerly, she had gone to church every day.

There were two old men from near Lalana, who used to come to Villa Alta on Monday's market to sell salt. They had a quarrel One of the old men became ill afterwards, and nobody could discover what the matter was. One of his friends noticed that every night a great bird like a turkey, used to come and perch on a branch of a tree near the house. By this time, the sick man was nearly dying The friend shot the bird and by morning, the sick man was quite well. The bird was killed on Saturday night. On Monday the old man went to the market in Villa Alta. He saw that his enemy was not there. He asked where he was, and was told that he died Saturday night.

[14] "Tiger" is merely the literal translation of "*tigre,*" the word used for the jaguar, which roams that country.

Doña Maria's father had a quarrel with his son, who became very angry with his father and said to him, "You will wake up dead (*Amanecerás muerto*) I am a *nahual.*" The father turned and hit him in the face and broke his nose, so that the blood came Doña Maria commented that if a *nahual* makes a threat, he can be rendered powerless to do harm if the threatened person hits him in the face until the blood comes

She also said that Jose Anacleto, who lives on his *rancho* near Lalana, is the only living *nahual* left, but she went on to add that *nahuales* get their power to change into animals from the smooth stone on the Cerro de Ocote just off the road to Playa Vicente, about half a day's journey from Lalana A power is received by praying to the stone. She told us that the *nahuales* from Latani stole the stone from the *nahuales* of Tepinapa

From another source,[15] it was affirmed that a village called Rio Tinto, near Tepinapa, was destroyed by the *nahuales* from Tepinapa, and the remaining families founded the village of Lachixila.

The Chinantec guide, who conducted us from Lalana to Choapam, said he had once shot an animal who was a *nahual.* He said that in order for a *nahual* to change into an animal he must go to a special place in the woods, where prayers and offerings are made. He must take off his clothes and roll naked down the hill, and as he rolls, he turns into a *tigre,* or a fox, or some sort of an animal.

A first-hand account of how a man became a *nahual* without realizing for some time that he was one was given to me at San Jose Rio Manzo by his wife, Magdalena Contreras, a much sought-after and well-known *curandera* in this district. The story is of special interest

[15] From Jose Cruz, now of Montenegro, formerly of Lachixola.

because it shows that a definite involuntary, psychological state may exist in an individual, which causes him to regard himself as a witch If it is possible to accept his wife's statement as evidence,[16] this report is the record of a psychological case,[17] which means that it is in a category quite distinct from mere folklore or a traditional tale Sufficient items of the life history of the individual are given as associations, thus making it possible to understand this case as one of dissociation of strong murderous and aggressive impulses, in spite of fantasy elaborations of his wife [18]

Told to Miss Natalie Scott and myself on May 27, 1936

My husband, who was from Lalana, was the eldest of a large family His mother and father were normal people He was given to fits of violent temper from childhood on I married when I was 16 and then went to live on a little cotton plantation below El Socorro on the Rio Manzo He was a good worker and kindly, except when he had his fits of temper, which would come on as sudden as thunder. When drunk, he was always violent and cruel In a fit of temper or when drunk, he would beat me with a stick or cut me with a *machete*.

After we had been married about 12 years, he began telling about the dreams he had. He used to dream that he was ranging the mountains, doing harm and killing lots of animals He would dream that he went to a place where there were lots of turkeys which flew away in great fright He would dream that he found himself in a place where there were dead sheep, calves or pigs, and he would know that he had killed them. He would also dream that he was chasing animals to kill them.

He asked me why he was dreaming such things and I said it was just foolishness. The dreams continued for three or four years, and worried him. He never thought he was a *nahual*.

One day he went to Playa Vicente on an errand When he reached the beach, he suddenly felt very sleepy and lay down and slept and dreamed that he was shot through the abdomen. When he awoke, he felt so ill he started home at once About an hour out at Boca de Savana, he saw the head of a *tigre*, which had been burned The people there told him that this *tigre* had been doing so much damage to the animals that a large group had gone out to hunt it They had shot it, skinned it, salted the skin, and burned the body

When he reached home, he felt very ill and blisters appeared on his hands and mouth and he didn't want to eat, but was very thirsty and he drank many jars of water because of the salt they had put on the *tigre* He realized then that the tigre was his *nahual*.

Four days after his dream and after having seen the head of the *tigre*, he died During this time, he complained of the pain in his abdomen, although there was no sign of injury there The night he died, there was a full moon I was alone in the house with him, while the two children slept, with all the doors closed. I heard something outside and my first thought was that it was a pig, but then I realized we had no pigs, I went to the door and opened it just a crack and clearly saw a *tigre* in the moonlight, snuffing at the house The *tigre* kept circling the house and snuffing and even scratching at the house Just before my husband died, the *tigre* roared several times I spoke to him about it and said, "Don't do me any harm, even if you are a *nahual*," and he said, "Don't be worried; it won't hurt you " After that, he died.

On the skin of the left shoulder of the *tigre* that had been killed, were seen the letters of my husband's name

In a previous work, I have given instances among the North American Indians of witchcraft, as well as many other aspects of culture arising from dreams [19] The above case is an example of a person realizing that he is a witch from his

16 Maria Contreras' husband had died four or five years before according to the statements of other individuals in her village, and at El Socorro nearby he was regarded when alive as a *nahual*, and was known to be a man of violent tempers.

17 In France cases of individuals who regarded themselves as werewolves and believed that they changed into wolves and roamed the country killing animals and children are recorded in the past. Cases tried at Angiers in 1598, and at Bordeaux in 1603 occurred in both of which the accused were convicted of being werewolves, but were treated as insane (*Encycl. Brit* "Lycanthropy.")

18 Maria Contreras spoke no Spanish but Juan Ramon Trinker, who spoke fluent Chinantec, acted as interpreter.

19 J S Lincoln, "The Dream in Primitive Cultures," p 75 The Williams and Wilkins Co, Baltimore, and The Cresset Press, London.

dreams. The content of the dreams, together with the items of life history, clearly show that violent murderous wishes and aggressive impulses, which are largely repressed, dissociated and projected onto external events are some of the psychological factors at the basis of nagualism as an actual practice. Proof of this is given by the fact that he identifies with the murderous *tigre* who was shot for doing harm to the neighborhood. There are obviously many more factors to nagualism both psychological and historical than mentioned here The above is merely a superficial analysis obvious to any psychologist

In conclusion, the traits that can be singled out to differentiate the southeastern Chinantla culturally from other sections are, the monosyllabic isolating Chinantec language with its many difficult tonal changes (with two dialects in the northern and southern sections);[20] the almost complete absence of handicrafts such as weaving and pottery making, although the people are close neighbors to the Zapotec experts in both these crafts, and the concentration of witchcraft belief, folklore, and practice. Witchcraft patterns are found throughout Mexico but appear especially concentrated in this region, and offer a most fruitful field of research for the psychologically trained ethnologist The report of the Pan-American Union of Mexico City now in process of being made is sure to present a more comprehensive study of this interesting and unspoiled area [21]

EXTRACTS FROM TWO UNPUBLISHED LETTERS OF LINNAEUS

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DURING the summer of 1937, Mrs. Smallwood and I were examining the letters and lectures of eighteenth-century professors at the University of Edinburgh in an effort to discover what the American boys who had studied at that great institution were taught in the realm of natural history. Among these manuscripts we came upon several letters exchanged between Linnaeus and Walker, which we found very interesting, and from which I am here including brief extracts For permission to copy and publish these Linnaeus-Walker letters, I wish to thank F. C. Nicholson, Esq, librarian at the University of Edinburgh

The possible distribution of one of the Alpine heaths in Scotland or Ireland—the mistaken interpretation of the capsule of the moss—the study of zoophytes as plants—these are among the natural history problems discussed by Linnaeus and Walker

> Si vous faites moi la faveur de Response diriger, S'il vous plait, par la route de la Poste,
> M John Walker Ministre de l'Eglise, de Glencorse, a Edinbourg, en Ecosse [Scotland].

Thus ran the close of the Reverend John Walker's first letter to "My Dear Sir, Linnaeus, Knight of the Pole Star, Physician in service of the King of Sweden, and Professor of Botany at

[20] Jaime de Angulo, "The Zapotecan Linguistic Group." *International Jour. American Linguistics*, 8 · 1, December, 1933

[21] I wish to express my thanks to Miss Natalie Scott, of New Orleans, whose thorough knowledge of Spanish and trained experience in the by ways of Mexico were invaluable to my wife and myself, and to Don Manuel Gracida, of Oaxaca, who so conscientiously and expertly guided us and our horses through the difficult and sometimes dangerous mountain trails.

Upsala, Sweden," written on January the eighth, 1762 The reading of these letters takes us back to that interesting period when men were beginning to bring a little more order into their observations; and their phraseology reveals a generosity and friendship in which we of to-day are too busy or too thoughtless to participate. I am grateful to Dr L W Sharp, of the library of the University of Edinburgh, who carefully checked the copies of these letters with the Latin originals. I am also indebted to Professor Perley Oakland Place, of Syracuse University, for their translation Their Latin, according to Professor Place, reveals numerous echoes of Cicero's style combined with colloquial freedom in the use of cases Although the letters were written in Latin, the complimentary endings were in French.

The four letters which were exchanged between these two men over a brief period of eighteen months throw much light on the interest taken in botany and zoology by the amateur preacher-naturalist, who was, in 1779, to become a professor of natural history at the University of Edinburgh, and the already-famous Swedish scientist.

When Linnaeus received John Walker's first letter, he was busy with a revision of his "Systema Naturae," which is popularly known as "the thirteenth edition" He had recently been presented with a gift from the King of Sweden and had been permitted to name the successor to his chair at the University of Upsala The time had come when Linnaeus was feeling the burden of his teaching duties, and he had written to Chancellor Höpken, at the university, that, "as he had regarded science more than his life, he had worn out his body, shortened his days, and brought on too soon the infirmity of old age "[1]

Walker clearly recognized the greatness of the man to whom he was writing; for, in his first letter he said:

> In the field of Botany (*In re herbaria*) you have seized, in advance of all, the palm of victory, so that you have ascended a pinnacle to which the discouraged hearts of others never attain. Your own genius has opened this path of glory, it has carried the torch, it has lifted the signal, it has laid firm foundations for your honors

The English Church at Glencorse was some twelve miles south of the city of Edinburgh, but this did not deter the young pastor, The Reverend Walker, from taking an active part in the intellectual doings in the city There was the university with its famous medical school, and several societies whose members were drawn both from the university and from those residents of the city and of nearby towns who were especially interested in natural history

These letters were partly concerned with an invitation to Linnaeus to become an honorary member of the Philosophical Society, organized in Edinburgh in 1739 Walker was very frank in telling Linnaeus about the manner in which the activities of the society had declined, and the eagerness of some of its members to revive them

> The Society that was established in Edinburgh to promote philosophical studies, although it has faded for a long time, is, nevertheless, I hope, to bloom again, and in the future (the members) will employ greater diligence, in order that Natural Science may gain increase; and their own work will be brought more often into the light of day I desire to know whether the volumes which this Society has made available to the public have come into your hands, or, if you have been without the opportunity of reading them, by what route they can be brought to Upsala. Furthermore, I ask you to inform me whether you wish ours to be the one of the Societies with which Linnaeus deigns to associate himself . . .
>
> Because of my regard for Botany I can scarcely endure with a calm spirit its present neglect I have desired to put an end to this neglect, and I have determined to ascertain whether it is possible. Impelled by this purpose, I seem to feel that the best plan is to present this science briefly and to make it easier at the

[1] "Linnaeus," B Daydon Jackson (London, 1923), 324

beginning, in order that by this plan the hearts of the young may burn with desire to learn Botany. And, furthermore, nothing could better contribute toward the attainment of this end than catalogues carefully compiled of foreign and native plants. This is apparent from the general agreement of Botanists, since by far the most numerous classes of Botanists are the "Adonistae" and "Floristae "

The lack of activity, or "present neglect," of which Walker complained, was probably due to the Scottish uprising in 1745 which aimed to place Charles, the Stuart Pretender, on the English throne. In 1752 the society's meetings were resumed; and in 1782 the "Philosophical Society" was rechartered as the "Royal Philosophical Society of Edinburgh "

Charles Alston's long teaching career was drawing to a close He had been trained at Leyden under Boerhaave, and was the last of the apothecary teachers He was an intense opponent of the new Linnaean system; and his final scholastic effort, after he had retired, was to publish a paper which he hoped would definitely refute the pernicious sexual system. "A Dissertation on Sexes in Plants "[2] But this last of the Edinburgh herbalists, or "Adonide," was to be disappointed; for the Reverend John Walker, seeking the favor and help of the man whom Alston had opposed, was laying the foundation for a different method of teaching, of which he was to be the first exponent at Edinburgh

At the time these letters were written, teaching at Edinburgh was of a practical nature and centered in herbal gardens, fundamentally established for apothecaries and medical students The maintenance of these gardens was so great as to make them impractical for general study Walker wrote that "a different way" must be found "according to which the hearts of the young may be inspired by this study " He lamented that the Scottish youth had neither a list of their local plants, nor was there a local herbal · ". . . we are equally destitute of Floras and Adonides [*sic*] Nothing of this kind is superior to the Compendium of Rajus," he said, but it, the *Compendium*, is not at all "suitable for Scotland, since the testimony of the authors relates only to regions of England "

Apparently Walker had made up his mind to "break" with the local teacher of botany, Alston, for he wrote "And since I have decided to follow the sex-system, I thought that it was best to consult the author of it " This long letter concluded with a description of the common moss, *Bryum striatum*

To this first letter Linnaeus replied as follows

Charles Linnaeus, Knight, sends greeting to John Walker, a most distinguished gentleman

For a long time now I have been grieved because, after my good friend I'sac Lawson died, I have not found in all Scotland a friend with whom I could discuss the plants of that region, and by whom I could be instructed in them And so with happy omen you, honored Sir, have come into my path Therefore, for both reasons, I eagerly receive your great service to me, and I acknowledge it with gratitude

There can be no doubt that Scotland will be found to rejoice in a great many very rare plants, not in the list of Rajus, nor in other accessible works, since your region abounds in very high Alpine mountains, forests, and waters. For many years I have left no stone unturned, that I might obtain one perfect specimen of the Erica Daboecii [3] Nor have I been able to obtain it, it is, to be sure, a plant of Ireland, and is not a native of Scotland, but I do not doubt that it is even found in your Alpine mountains . . .

I have read the Edinburgh Proceedings, [*Proceedings*, Philosophical Society of Edinburgh], which are for physicians the most excellent proceedings of all the learned Societies In them I have found but few things pertaining to

[2] Charles Alston, "A Dissertation on Sexes in Plants," from *Physical and Literary Essays*, I, second edition (1771).

[3] Through the courtesy of H D House, Esq., New York State botanist at Albany, we learn that "*Erica Daboecii* (Linn Sp Pl. ed 2, p. 509) is now designated as *Daboecia polifolia* Don (Ericaceae), and related to Erica. Distributed from northern Spain and adjacent France to Ireland."

Botany, except the species of *Caldenii*[4] and *Hyperici*[5]

You ask whether I should wish to be received into this famous Society; I do not see how it could be done, as long as Cl——— is a member, [*atro carbone*] who has put such a black mark against my name.

It has been difficult to interpret the meaning of Linnaeus' expression, "atro carbone." Our first thought was that "black-balled" was indicated; but Mr. Nicholson, librarian of the University of Edinburgh, doubted there having been any such action as "black-balling" implies We then sent a copy of the complete paragraph to Dr. M L. Green, at the Royal Botanic Gardens in London She, in turn, submitted the problem to Mr. Savage, of the Linnaean Society—and three possible translations were thus suggested, from which we have selected the most literal[6] We have also considered whether the "Cl——" might not be "Al——," meaning Alston, but there seems to be no doubt but that Linnaeus wrote "Cl——," and we are unable even to guess as to whom he refers

Walker attempted to fit his observations on the moss, *Bryum striatum,* into the taxonomic pattern used for flowering plants as male and female flowers.[7] This mistaken observation excited Linnaeus and he wrote:

With amazement I read your description of the *Bryum Striatum,* and with great impatience I am awaiting the first days of spring, when I can search for the male flowers of this *Bryum,* which you first discovered and thus anticipated me, surely if I shall find in it the eight named *stamina,* that moss, with your observation, will unlock a new chamber of Nature, through which we shall enter a hitherto hidden palace of Nature, nor will there be a doubt that we shall have similar success in the other mosses. If this should happen, as I ought not to doubt your eyes, surely it would bring to you immortal fame. As a result of this one experiment I do not doubt that you are one of the keenest Botanists.[8]

Continue, as you have begun, and enter the hidden places of Nature, and conquer new kingdoms there; and, furthermore, keep in your heart your love for me

Upsala, February 22, 1762

If you write in reply, address your letter to The Royal Society of Sciences of Upsala; I open all its letters.

Walker was successful in his request

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4 Mr. House also tells me that "It is extremely likely that the name '*Caldenii*' refers to *Coldenia,* a Linnaean genus of the Boraginaceae There is no botanical generic name Caldenia (or -ium)."

5 According to Mr House, *Hyperici* would naturally, as I had suggested, refer to *Hypericum.*

6 Dr. M. L Green suggested in a letter to the writer: "Therefore I think it is better to translate the passage in one of the following ways 'I do not see how it could be done as long as Cl—— is a member who has attacked me so virulently,' *or* ' . . who has disapproved of me so strongly,' *or* ' . . who has put such a black mark against my name ' "

7 With Walker's first letter to Linnaeus, he enclosed the following, together with drawings of plants·

Character of *Bryum striatum* (Sp Pl p. 1115, n. 2)

Male flower	terminal, solitary, sessile.
Filaments	eight, compressed, connivent, of which the four in the middle are shorter
Anthers	eight, blackish purple, sub-rotund, incumbent, sprinkled with purple powder.
Receptacle	foliaceous
Female flower	terminal, solitary, on a different plant.
Peduncle	very short, filiform.
Calyx ..	calyptra conical, striate and pale.
Pistil	ovary ovate . . . Opercular style deciduous, spherical at base, filiform toward the apex. . . . Stigma acute.
Pericarp	Capsule ovate, unilocular, the mouth with slender teeth.
Seed	powder-like.
Receptacle	foliaceous.

8 Dr. M. L. Green, in a letter to the writer, said: "The scientific problem involved in the life cycle of mosses was fully cleared up in Hofmeister's 'Vergleichende Untersuchengen,' published in 1851. An English translation, produced by the Ray Society in 1862 under the title of the 'Higher Cryptogamia,' included also his cognate researches on the Coniferae. This great synthesis, which brought alternation to the front, has proved itself to be the foundation for all subsequent morphology of land-living plants "

that Linnaeus be made a member of the Philosophical Society, as shown in his second letter, dated October 12, 1762.

I have received your letter written at Upsala, a most welcome letter, since I learned from it that you are well. With very great pleasure I welcome this opportunity to inform you, at the request of the Edinburgh Society, that on June 17 you were unanimously elected to membership. On the same day John, Count de Bute, and his brother, Mr Steuart McKenzie, natives and ornaments of Scotland; one, to-day governor of the whole British Empire; the other, envoy to the king of Sardinia, these were received into this Society.

I have explored the Scotch mountains this summer in quest of *Erica Hibernica*,[9] but thus far to no purpose. Ireland at this time provides no one experienced in the field of Botany I have written to the Bishop of Ossory (Mr. Pococke, Asiatic traveller), and to a physician in the town of Dublin, and, if the matter turns out well, you will hear later.

To return to the first letter, referring to his proposed list of plants, Walker said·

To this *Flora* I have decided to add a catalogue of the Submarine Zoophytes, of which very many are found on the nearest shores Accordingly, I have chosen this opportunity of leading those who are interested in the science of Botany to a knowledge of these sea-offsprings, not a few have the opportunity in warmer regions to examine the Zoophytes while these are still alive. In the history of these, much is lacking, since thus far they have been examined in carefully preserved specimens. Although animal life plays the principal part in these mixed bodies, nevertheless, when they are arranged in order, they should, I think, be considered plants rather than animals, because their species can best be investigated from their ramification and external appearance, rather than from the microscopic living things that constitute them and dwell in them.

To which Linnaeus replied. "I do not doubt that you can wonderfully enlarge the history of Molluscs, Zoophytes, Lythophytes,[10] even now incomplete. I wish that you would undertake this."

Linnaeus, at this same time, was carrying on an active correspondence with John Ellis, who was the foremost student of corals, and was maintaining in a letter to Ellis, dated September 16, 1761, that:

Zoophyta are constructed very differently, living by a mere vegetable life, and are increased every year under their bark, like trees, as appears from the annual rings in a section of the trunk of a *Gorgonia* They are therefore vegetables, with flowers like small animals, which you have most beautifully delineated. All submarine plants are nourished by pores, not by roots, as we learn from *Fuci*. As Zoophytes are, many of them, covered with a stony coat, the Creator has been pleased that they should receive nourishment by their naked flowers. He has therefore furnished each with a pore, which we call a mouth. All living beings enjoy some motion.

The Zoophytes mostly live in the perfectly undisturbed abyss of the ocean. They cannot therefore partake of that motion, which trees and herbs receive from the agitation of the air. Hence the Creator has granted them a nervous system, that they may spontaneously move at pleasure [11]

Corals were classed as Lythophytes, and sponges and Hydroids made up the Zoophytes. It was more than fifty years after the dates of these letters that these terms were finally given up The name "Porifera" was adopted in 1835, and "Coelenterata," in 1848

As we read further in these letters, we see that rare plants and Zoophytes were but phases of the interests of Linnaeus. Mr Alexander Dick's practical manufacture of paper from plants—his own correct information about the metamorphosis of the May-flies—his credulity in partially accepting Walker's description

[9] On consulting Mr. House, I learned that "*Erica hibernica* Syme (and apparently Linnaeus did not coin this name) is a synonym (fide Index Kewensis) of *Erica mediterranea* Linn. Distributed from Ireland through southern Europe."

[10] "Zoophyte" is an old term, having been used by Aristotle. It was more than 2,100 years later that these "animal plants" were correctly interpreted. "Lithotype" was used by Sir T. Browne, in 1646: "That Corall (which is a Lithophyton or stone plant." Lyell, in 1875 retained this term. It was used much later for lichens and mosses by Kerner and Oliver.

[11] *Correspondence of Linnaeus*, compiled by James Edward Smith (London, 1821), I, 151.

of the moss flowers—all reveal the character and scope of the famous Swedish naturalist's mind.

Walker wrote:

Recently I have observed *Ephemera* to shed its skin entirely, and that instar to shed a skin while in the winged stage of its life I do not know whether this metamorphosis has been observed by others; I have noticed it in all the specimens of Ephemera .

In this packet of letters you will find specimens of paper, and of the plant from which it is made A large supply of this paper was made in the beginning of the present year by the noble Sir, my most upright friend, Mr Alexander Dick, Golden Knight, most worthy President of the Royal Edinburgh College of Physicians. This aquatic plant grows in very great abundance in ponds at his villa near Edinburgh, and I wish you to inform me whether it is *Confera Bullosa, Syst Nat*, p 1346, n 3 He asked me to send to you, with his best wishes, these specimens, along with the paper, named *Linnaea* after his daughter

Linnaeus, in his second letter, first acknowledged the honor of his election to the Philosophical Society, then commented on the specimen of paper, which Walker had sent to him.

A most friendly letter, written by you last year, in fact, on October 12, I received fourteen days ago, I do not know where it has remained unnoticed so long With deepest gratitude I acknowledge the esteem with which the illustrious members of the renowned Society of Edinburgh have received me, when they wished to adopt me as a member of their Society Would that I could return their kindness in a manner worthy of them! You recommended me, I hope without detriment to your reputation

I am sorry that *Erica Hibernica* has withdrawn from its fellow-countrymen. But, if Alpine, I know by experience how difficult it is to find Alpine plants. I am astonished at his skill in making paper from a water-plant; certainly it is a beautiful success, I think that it must be the *Confera Bullata*, everywhere of most frequent occurrence; surely it can be prepared from other water plants. I certainly wonder that Mr. Alexander Dick could have foretold this. Please greet the noble maid who has inscribed this paper with my name.

In regard to the metamorphosis of the *Ephemerae*, the fact is very well known among Zoologists The specimens of *Bryum Striatum* were beautiful, but even now I doubt whether they are true stamens, or another off-shoot; surely in most mosses the *anthera* is concealed in the cover (*operculum*) itself, as I have shown in my dissertation on the *Buxbaumia* I wish that you would undertake the task of proving this, and that you would consult many: you can best do this, I can not, as I am not in the city. . . .

These brief extracts from the correspondence of the two naturalists, one the great Linnaeus, give an intimate and accurate picture of the activities of the two men, and carry within themselves their own interest The letters are long, but the extracts which I have made include all the matter of any considerable scientific importance. According to Dr. L. W. Sharp, who has charge of the department of manuscripts in the library of the University of Edinburgh, these Linnean-Walker letters have not heretofore been published

THE EXACT SCIENCES IN A LIBERAL EDUCATION

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BEFORE attempting to discuss the place of the exact sciences in a liberal college curriculum I should like to briefly define what is meant by this title. The exact sciences are physics and chemistry, though mathematics, considered as a body of knowledge based upon experience, is included as well Physics, with its contacts with mathematics on the one hand and chemistry on the other, and its vast fields of practical application, is the most representative division of the exact sciences and provides the best illustrations of the scientific method The word liberal, however, is more difficult to define It has seven or eight specific meanings for the lexicographer, and any one who has followed the recent correspondence in the magazine *Time* regarding the liberalism of President Roosevelt realizes that it has as many popular meanings as there are interpreters My understanding of the word as applied to education is merely the differentiation of the general term from technical and professional instruction The rôle of the sciences in the professional fields is so obvious as to need no discussion, but there is often a tendency to consider that science is only the concern of the technician and that it is for him merely a tool to be used during the forty hours per week in which a benevolent government permits him to work This is much too narrow a view, for the exact sciences occupy the most important position in any modern curriculum designed to produce a liberal education

I should, perhaps, exclude the case in which liberality has been carried so far as to have become a travesty on education. If the educator is so liberal that the educatee is free and untrammelled to wander at will through the academic grove, choosing what fruits please his immature fancy to the great detriment of his intellectual digestion, there is no need for the educator and little occasion to have any of the fruits of the exact sciences available These fruits would not mature in such an uncongenial atmosphere, and should they perchance be selected, there is little likelihood of their being digested. The extreme example of this is a program made up of elective survey courses Such a curriculum overlooks the fact that it is necessary to know at least one thing well and establish a firm basis of competence over some small body of knowledge before proceeding to a broader understanding of other fields To reverse this order at the approach of intellectual maturity is the underlying cause of intellectual slovenliness and superficiality Such complete liberty of choice, based on the idea that the student knows what is best for him and that he is always right, amounts to license, and a faculty is greatly at fault if it does not chart certain general paths or sub-curricula to be followed by different students according to their bents, in order that they may acquire a conception of the organization of a field of knowledge.

The question as to what the well-educated man should know is too broad to be answered except in the most general terms He must, of course, be able to read and speak and write his own language. To make the last two accomplishments of any value to others than him-

self, he must be able to carry out certain simple logical thought processes. To this minimum should be added as wide an acquaintance with his cultural background and surroundings as he can obtain; this involves some familiarity with other languages, history and the arts. Finally the process of education is incomplete if the seeds are not sown that will result in the student himself making some contribution to the diffusion, application or enlargement of knowledge for his own sake and that of his fellows. The rôle of exact science in education will be considered in terms of these three categories: as a training in exact thought, as the basis of our modern culture and as the main stem of our intellectual growth.

Consider first the development of logical habits of thought The nature of science and the discipline it imposes provides the best possible training in accurate reasoning. Just as the trivium of grammar, rhetoric and logic provided the mental discipline of the medieval schools, this same discipline is provided to-day even more strictly by mathematics and the sciences. The necessity for ordered and accurate mental processes is not realized by the intellectually immature any more than a child understands why jam is an unsatisfactory diet. But it is the chief duty of the instructor to point this out by precept and example; to "Learn, never grudge the pang; strive, never grudge the throe." Good mental habits can not be instilled painlessly, but the net return to any man on a mental investment is directly proportional to the effort and assiduity he himself has expended. As in starting a savings account, the first deposits are not easy to make. Study is not a heroic emotional action, but is undertaken only upon good advice and guidance. Nothing could be more valuable than a good set of skeptical, analytical and logical mental habits once they are acquired. As William James writes: "As we become permanent drunkards by so many separate drinks, so we become saints in the moral and authorities and experts in the practical and scientific spheres by so many separate acts and hours of work. Let no youth have any anxiety about the upshot of his education, whatever the line of it may be. If he keep faithfully busy each hour of the working day he may safely leave the final result to itself He can, with perfect certainty, count on waking up some fine morning to find himself one of the competent ones of his generation." Beware what you set your heart upon, for it shall surely be yours. The intellectual maturity represented by a disciplined mind is a thing greatly to be desired.

Accurate habits of thought are acquired by one who studies the exact sciences. In addition, the mastery of a science results in the confidence engendered by an intellectual triumph that makes subsequent tasks easier. Science teaches its student the principles of logical method He knows a premise or an axiom when he sees one, and he knows how to use rigorous syllogistic reasoning to obtain conclusions in which he has confidence He realizes that in so doing he has elicited no new fact, but merely altered his point of view, though this is frequently most fruitful in leading to the revelation of new and suggestive relationships. Science brings out most clearly that careful observation is the raw material of accurate thought. If the original data are in error no amount of correct reasoning will provide him with significant results, for nothing will emerge from any amount of ratiocination that is not inherent in the premises. Conversely, if his data are correct, but his reasoning is not rigorous, he will be led into error. Finally, a study of science provides him with the essential technique for checking his conclusions by resorting to additional observation and experiment. This appeal to the facts is always the court of last resort. The prediction of hitherto un-

suspected facts and their subsequent experimental verification represents the culmination of man's logical rational endowment.

If this method were really understood in its true inwardness and applied by all educated men, the world would be a simpler and less fretful habitation. As an example, I have heard one of our leading political and social scientists say that the implication in the word science applies to this subject more from hope than from achievement. In this field the data are hard to get and require a skilful and impartial sorting and interpretation that they are seldom accorded. The pressure to avoid wishful and non-rigorous thinking is resisted only by the most independent exponents of intellectual honesty What valid conclusions can be drawn are more frequently than not distorted or wilfully misinterpreted by special pleaders The fact that errors are committed and incorrect results reached is concealed by pride and special interest rather than exposed by unbiased analysis. The emotional element that is injected into matters concerned with our livelihood or human relationships has so far retarded the application of the rational methods of science that it is rare to encounter a political or social decision that has been based on the pertinent facts or merits.

I am not such a pessimist as to believe that we can never surmount our primordial instincts, emotions and narrow self-interest, in those matters where the common good so demonstrably requires rational ideals and behavior. But it is unlikely to be accomplished rapidly by the methods, if they can be called such, at present in use The difficulties that are encountered in extending the nice interplay of induction and deduction, which characterizes the scientific method, beyond the inanimate spheres are most formidable and must be clearly recognized The most difficult stage in the organization of any field of knowledge is the first one in which the qualitative laws are formulated and quantitative procedural definitions are established Clear, precise definitions are an essential for subsequent quantitative development. Outside the sciences there is no established precedent and the first steps carry little conviction. Whitehead makes the following statement in regard to mathematics, which is true to an even greater degree for the physical sciences and is probably the reason that other branches of knowledge have not even reached the first stages of ordered description "In mathematics the greatest degree of self-evidence is usually not to be found quite at the beginning but at some later point; hence the earlier deductions, until they reach this point, give reasons rather for believing the premises because true consequences follow from them, than for believing the consequences because they follow from the premises." The initial inductive processes which lie at the very foundation of any organized field of knowledge carry little conviction in themselves They, and the subsequent inductive and deductive steps, acquire cogency as we gain confidence in the correctness and significance of the conclusions The exact sciences have developed somewhat past this point and the existence of a well-tested theory lends credibility to a conclusion, though the last word is always with experiment. But in the other branches of knowledge the degree of establishment of the fundamental principles has yet to reach the stage where they are really valid evidence for trusting conclusions based upon them. As this is the slowest and least encouraging stage of development our current failure to live logically is no cause to despair of our ultimately applying the scientific method to the less exact sciences and to human social and political activities.

The bed-rock of rigorous method rises closer to the surface in mathematics and the physical sciences than anywhere else

in the curriculum, because of the simplicity of the fundamental concepts that are here involved and the formal symbolic structure that has been developed for the reasoning and the statement of conclusions. Unfortunately, there is no analogous structure available in other fields of learning, and ordinary language must be used. The limitation thus imposed constitutes one of the chief difficulties both in the formulation of definitions and in their subsequent discussion. As Whitehead says: "The appearance of contradiction is always due to the presence of words embodying a concealed type of ambiguity, and the solution of the apparent contradiction lies in bringing the concealed ambiguity to light." Words, however, must be used in any extension of the scientific method, for no formal symbolism such as that of mathematical logic exists in other fields. But they must be used with the greatest care and the utmost suspicion in view of our extreme fallibility. The implications and connotations of many ordinary words are such as to largely unfit them for the precise expression of ideas. Just as the word "liberal" may have a number of so-called "specific meanings" and an indefinite cloud of associational significance for each individual, so do all but the simplest words. The technical perfection of the transmission of speech is such that our voices can be made audible on the opposite side of the world, but unfortunately the communication of ideas from one head to another is in no such satisfactory state. With only the imperfect channel of language available it is highly dubious whether ideas can ever be transferred with sufficient precision to justify certainty of conclusion. It is merely a pious hope on my part that the mental images aroused in you by the words I write have some few fundamental characteristics in common with what I have in mind. The limitations that are thus imposed on the ordinary discourse of politics, art, literature, and so forth, must be explicitly recognized if the grossest errors are to be avoided. The pitfalls inherent in the careless use of words and loose argument are particularly evident to one who is familiar with the discipline and rigor of science. It is clear to him that the predictions of a scientific theory have a strong *a priori* probability only because of the soundness and adequacy of the underlying data and the correctness of the reasoning based upon them. A familiarity with these methods acts as a touchstone with which to gauge the relative cogency of any conclusion. If the data are dubious or incomplete or if the reasoning based upon them is ambiguous, argument is pointless. The conclusions may or may not be true, additional observations will alone decide, but they receive no *a priori* support nor do they suffer any prejudice from what is essentially an irrelevant argument.

In considering the second aspect of the rôle of science in education, the various authorities display more unanimity of opinion than might be expected in defining education as the introduction of the maturing individual into the life and culture of the group. The most succinct definition of culture is that it is the intellectual content of civilization. As our present civilization is particularly characterized by its scientific achievements, the exact sciences are the most cultural subjects in the curriculum. Malinowski goes somewhat farther in the Encyclopedia of the Social Sciences and states that: "Culture consists of a body of commodities and instrumental artifacts as well as customs and bodily or mental habits which work directly or indirectly for the satisfaction of human needs." This introduces a second cultural aspect of science as including the material products of its application. A Hospital, the Empire State Building, the Pennsylvania Railroad and the *Queen Mary* are most striking symbols of our culture, and all

the principles of their construction and operation are based directly on the exact sciences.

The flowering of the scientific method is the chief intellectual triumph of our civilization judged both by the subjective satisfaction it yields and by the objective results that it has achieved. At present it is less widely applied than its potentialities warrant, and the full force of the method has been felt but little beyond the fields of mathematics and the exact sciences. In these fields one sees clearly the successive stages of development associated with the scientific method There is the initial accumulation of qualitative data, which suggest relationships between observable quantities. This is the most difficult stage of development, as it involves the formation of new mental concepts and connections Then follows the quantitative formulation, including the establishment of the essential definitions, in order that the subject-matter may be clearly and unambiguously stated. This inductive process leads to the theoretical structure which takes on more definite and detailed form by further experimental accretion A well-made, crucial experiment is the fundamental building stone in the scientific structure which is held in a unified whole by the connections of theory. Unessential protuberances and excrescences are later pruned away by the introduction of the axiomatic and deductive point of view The essential fundamental concepts and crucial experiments are winnowed from the inevitable chaff that accompanies the first gropings for an ordered description of phenomena, which characterize the initial stages of a science The theory is modified and extended, its interpretations are broadened and frequently its outlook is completely reversed without in any way disturbing the foundations which were built on careful and accurate data of observation. The final test of a scientific theory is its fruitfulness; the verifiable predictions that it makes. These predictions are all inherent in the original data, though they are not immediately obvious, but are suggested or brought to light by logical deduction A theory that is not forward-looking and does not lead to significant extensions and advancements is merely a beautiful but sterile structure of the imagination.

If science is understood as an ordered quantitative description of material data, many of the misapprehensions regarding conflicts with human emotional processes are avoided. Science has nothing definite to say about what it can not define procedurally and measure quantitatively. Oddly enough it has no concern with what I believe to be the popular conception of reality, as the accurate correspondence of our observations with some transcending unobservable actuality. No scientist would contend that any theory or entity introduced to simplify description has reality in any such unscientific sense It is no part of the physical sciences that an atom or electron is real, or that a theory is true, in any other implication than that it predicts correct observable results, and leads to hitherto unrealized relationships. On looking back over the historical development of the sciences it is evident that many of the false starts and blind alleys that have temporarily impeded progress have been due to over-active imaginations, which have carried analogies to unjustified extremes and clothed conclusions, that could not be directly tested, with an unwarranted and incongruous significance In physics we speak of an electron or an atom as a particle, but in so doing, we realize that we must not complete the implied analogy and endow these entities with such characteristics as: shape, color, localized boundaries, hardness, and so forth, which are not their attributes at all Analogies and the mechanistic visualization of atomic or biological processes are frequently most suggestive, but if

their implications can not be tested, they are to be regarded with suspicion.

Popular interpreters of science tell most interesting and instructive stories and fill an important place in our society. The fact that they cloak their material with a specious simplicity is hardly a valid objection to their method, for in essence science is simple once it is thoroughly understood. Too often, however, they do not sufficiently guard the reader against unjustified extensions of their arguments by stating with sufficient clarity the limitations imposed on the validity of their conclusions More confusion than insight is apt to result from the elaborate exorcism of imaginary bogies, such as the conflict between science and the arts of religion This is mere windmill tilting, and it would be better to point out the complete isolation of science from concern in any but intellectual and material problems Fields having no point of contact can not by any stretch of the imagination be in conflict. The matter is not clarified by the dark sayings of certain mathematicians who have modestly referred to God as "The great mathematician," "The great geometer," and so forth. The undefinable subject of this statement can never *per se* be endowed with any scientific significance Aphorisms of this type are the result of some mental configuration that the authors wish to express in words, and they doubtless conjure up some hazy mental picture in the minds of the auditors as well. But it is idle to endow such statements with any objective significance, and preposterous to presume that the author and auditor have even remotely the same thing in mind. I believe that God has never been called a great scientist, which is due less to our inherent modesty than to an attitude of mind that inhibits such a meaningless concept.

A discussion of the scientific contribution to our civilization through the material evidences and artifacts that have been evolved would lead us too far afield. But their effect on our mental processes and the reaction of material and technical successes on our ordered thought is a definite phenomenon of the culture of our age, and as such, deserves brief comment. The importance of this aspect is recognized by Gilbert Murray when he writes: "A machine is a great moral educator If a horse or donkey won't go, men lose their tempers and beat it; if a machine won't go there is no use beating it. You have to think and try till you find out what is wrong. That is real education." There is much truth in the idea that we receive a very direct type of intellectual and moral education from our own mechanical devices. A machine is a self-evident proposition that is a most convincing argument for scientific principles. The simplicity of its elements when they are taken apart and lie before you, its direct functional character with nothing unessential or extraneous, its speed, precision, and rhythm, and the satisfying sense of ordered consequence it evokes are all educators. I have no doubt that they have restored to many men their confidence in the ultimate rationality of their universe, when faced by the unjust, irrational and feckless conduct of their human companions. It is not surprising that a racial predilection for metaphysics should lead Kipling's McAndrew to rationalize the universe satisfactorily to himself in terms of his ship's engines, and to see "Predestination in the stride of yon connecting rod." A skilled artisan is to some extent an educated man, not alone through the skill he possesses, but because of the mental habits formed by his association with mechanism. This is evident to me when I contrast the garage mechanic of to-day with the livery stable man of my boyhood. Here are men more or less comparable in formal instruction and with little, if any, book-learning But there is no comparison in their intellectual acuity and in

their logical handling of material or mental processes. Of course, they are eminently practical men and do not tend to generalize from their machines to themselves and their companions, but the germ of the concept and methodology is there, and they are potentially better citizens of an ordered society.

Finally, the third and most important aspect of science for its real students is the end which it itself provides The goal of a student varies with his training, temperament and degree of natural endowment, and it seldom becomes apparent before several years of study and training in the ideas and methods of a science. Then, however, a student gradually becomes aware of an abstract logically beautiful structure embodying what generations of scientists have succeeded in quarrying from their physical environment, and shaping through careful analysis and interpretation till the stones fit keyed together in an unshakable edifice It is a Spanish Castle of the intellect rather than the imagination, but if its outlines are clearer and more austere, it does not lack beauty, for it is the flowering of human capabilities in this sphere. The comprehension of this structure is alone an adequate recompense for a student who has persevered through the rocky and arid approaches that repel the less pertinacious The ability to explore its halls and study the perfection of its structure and detail is a never-ending source of wonder and intellectual gratification. I would add to Kant's "Starry sky above me and moral law within me" this structure of natural law about me. The understanding of man's scientific achievements is a very worthy end of a liberal education, and it does often constitute such an end for the more contemplative temperament or for the man who must for one reason or another terminate his scientific education at this stage.

But the chief beauty of the structure for the more active and inquisitive temperament is the fact that it is unfinished, and incomplete, and will always be so. There is no more genuinely satisfying activity than in adding to it, and in completing small portions of the edifice by building on the work of others. Few of us have the ability to lay corner-stones or to envisage unbuilt wings, though this is often done unwittingly in the prosecution of what appears to be merely a routine research, the significance of the results being frequently unrecognized at the time. The necessary work of rounding out the structure and filling in the detail, which is indispensable groundwork for the larger developments and which brings in its train immediate valuable application, is work that any one qualified by temperament and training as a scientist can do. The true scientist is characterized by the 'satiable curiosity of the Elephant's Child which is piqued by all the little unexplained facts that are constantly being encountered This curiosity is a driving force that can no more be ignored than the pangs of hunger, and when disciplined by an adequate scientific training, it leads on to the discovery of significant connections and generalities which broaden the front of knowledge. The only danger in the formal instruction and discipline which is a necesary preparation for a scientific career is that this curiosity may be withered and stultified for lack of opportunity to gratify it as it develops.

The real student is not taught, he learns. Our formal instructional schemes are, or should be, designed to facilitate this process in every way. A spark of interest and curiosity is worth an entire bonfire of reports, themes and theses A student should be encouraged to make some original contribution to his subject, however small, at the earliest possible date in order that he may feel that the subject is his, and that he may have some small competence in a very limited field rather than that he should be in awe of a vast structure of learning, which he can

never hope to grasp in its entirety. If he has the opportunity to acquire his scientific training through assisting in research, his curiosity is sharpened and his appetite is whetted for greater accomplishments, and he is well started on the road that will lead him to the greatest of satisfactions and from which he will never wish to turn back

This method of approach which develops the ablest men in science requires more equipment and better facilities than those that are adequate to merely expound what others have done. However, the added impetus that can thus be given, and the quality of the results obtained are its ample justification Furthermore, the type of instructor must be suited to the method, he must be a teacher by inspiration who is a guide and mentor pointing out those things that are most worth doing and suggesting the most fruitful methods of approach and the appropriate techniques. His personality and attitude are of the greatest importance, for he teaches by contact and example He can frequently impart his own consuming interest and vital concern in the growth of science Once the source of energy has been fired within the student himself he goes on under his own power to acquire with avidity the necessary details of his subject. He develops rapidly when he sees the obvious necessity of mastering his field in order to go further and contribute still more to our sum of knowledge The contrast between the method of leading a reluctant student by the hand through all the byways of known facts and techniques, before permitting him to try his wings at original contribution, and that of stimulating him as early as possible by contact with the spirit and methods of research, is that between the slow grinding locomotion of a car driven by its starter and battery, and the same car when the ignition switch is thrown and it surges ahead on the power latent within the engine itself. With a vital interest in broadening the bounds of our understanding of natural phenomena, with a background of acquaintance with the pertinent surrounding culture, and an equipment of technical competence, his formal education is complete. Like Ulysses, he will then set out "to follow knowledge like a sinking star beyond the utmost bounds of human thought."

BOOKS ON SCIENCE FOR LAYMEN

CONSIDER THE WEATHER[1]

SIR NAPIER has enlarged his delightful drama by nearly 40 pages, and our only regret is that he did not enlarge it more, for all he says is both interesting and informative The idea of superpersonifying the weather into a drama for which the whole world is the stage might occur to almost any creative writer of artistic mood, but only the abundant knowledge, the facile pen and the ready wit of Sir Napier could make real, as he has made real, this daring dream

The 48-page prologue deals with "Pageantry in the Sky"—clouds of various kinds, the rainbow, snow crystals, lightning and mirage—all well illustrated and clearly described This pleasing introduction is followed by an informative account of what the more highly cultured of the ancient peoples—Babylonians, Hebrews, Greeks and Romans—thought about weather phenomena Many of them, like Aristotle, explained natural phenomena as owing to natural causes Many others, however, and eventually practically every one, regarded all weather phenomena as special acts of the particular god or gods they themselves worshipped—an increase, perhaps, of abiding faith at the expense of robust reasoning To-day we look again for natural causes of the state and condition of the sky, just as Aristotle did twenty-three centuries ago, with our faith reserved for things unseen. None of these cultured ancients, Sir Napier tells us, had any word for "weather," just such expressions as "cold period," "wet time" and the like Don't blame them, for the generalized concept is not very precise, nor as easy to formulate as one might suppose Try it

Thousands of years ago weather sequences were carefully noted, especially in relation to husbandry and shipping, and much of this information was embodied in terse and useful proverbs Soon, however, many false signs got mixed in with the true, and then the whole lain over with the sickly hue of astrology. Still, good grain survives in the abundant chaff, if only we take the trouble to winnow it out

The various weather elements, and how they are measured, are discussed in some detail; and the information gathered by means of the instruments clearly set out with many maps and diagrams

Any one can read "The Drama of Weather" with pleasure and with profit, and the more he already knows about meteorology the keener will be his enjoyment of this book

One little caution to the American reader When Sir Napier says, impressively, that there are 10 billion tons more air over the northern hemisphere in January than in July, an American would say eleven trillion more That, of course, is because the Englishman's ton is one tenth greater than the American's ton, and his billion a thousand fold the American's billion Sometimes words are quite confusing; if an Englishman, for instance, should give an address on shearing hogs his fellow countrymen would know that he meant *sheep,* whereas all Americans present would feel certain that the crop would be more noise than wool!

W. J. HUMPHREYS

[1] *The Drama of Weather* By Sir Napier Shaw Second Edition Illustrated. xiv + 307 pp. $3 50. Cambridge University Press (Macmillan)

FIRST VOLUME OF SIGMA XI LECTURES[1]

THE results of one of the most significant movements in the American science scene of the past few years, the intellectual Chautauqua circuit for Sigma Xi chapters that is in successful operation for its third year, are brought by this volume to many who were not able to be in the audiences of the eminent lecturers at the universities

As Dr Harlow Shapley, of Harvard

[1] *Science in Progress.* Edited by G. A Baitsell. Illustrated xiv + 322 pp $4 00. Yale University Press.

University, remarks in the foreword, "an encyclopedist of a century or so ago could gather into fruitful comprehension the facts and theories of all branches of science." That can not be done to-day, so vast is the scope of science. And even this compilation of the Sigma Xi national lectures of 1937 and 1938 can hardly accomplish this task But, as Dr. Shapley observes, there is a unification of another sort, a theme of technique that runs through all the contributions to knowledge in these chapter-lectures. Many of the same technical tools are used throughout the various branches of science, and there is the general use of "the most common instrument of all reasoned experimental science—the balanced alternation of guiding hypothesis and experimental test"

It is altogether fitting that the men who do significant and important research should tell others about it, not alone in the technical articles of their specialized fields, but upon the lecture platform where their fellow workers and intelligent laymen may see them and hear their own presentations. Discovery and experiment is but the beginning of scientific progress Research must be understood, spread into other minds, and perchance applied. The lecture method may seem to be rather old-fashioned in a day of nation-wide radio hook-ups, wide publicity through press and magazine, and motion pictures. There is still the warmth and reality of the personal platform appearance that has many advantages.

To a large degree this personal contact between scientist and audience exist in this volume so far as print and pictures can reproduce it. The ten eminent scientists are talking to an intelligent audience about the work they have done, foregoing the shorthand of technical jargon that is proper and useful in the merely technical report.

Sigma Xi's national president, Professor George A. Baitsell, of Yale, has brought together with care and pleasing format the ten chapters, ninety illustrations, twenty tables and ample references to the original literature. The range is from atoms to elephants.

Professor E. O. Lawrence, of the University of California, tells of atoms, old and new, giving survey of transmutation and atomic synthesis in relation to the world of elements and living things. Nobelist Harold C. Urey, of Columbia, discusses the important separation of the isotopes and their use in chemistry and biology The new knowledge about the viruses, those entities in the borderland between the living and the non-living, is the subject of chapters by Dr. W. M. Stanley and Dr. L. O. Kunkel, both of the Rockefeller Institute for Medical Research at Princeton. Dr. Karl E Mason, of the Vanderbilt School of Medicine, discusses vitamins and hormones, while Dr. R R Williams, of Bell Telephone Laboratories, tells of the general rôle of his beloved and important thiamin vitamin in living things. Dr. Edgar Allen, of Yale, speaks authoritatively upon the internal secretions in reproduction. Taking us into the intricacies of the chromosomes, Dr T. S Painter, of the University of Texas, assays their application to genetics The important problem of electrical potentials in the human brain, which seems to touch upon the essence of life itself, is the subject of the chapter by Professor E. Newton Harvey, of Princeton University. Living physiology in one of its most important phases, metabolism, is the subject of the contribution of Dr. Francis G Benedict, of the Carnegie Nutrition Laboratory, Boston, and he has studied animals, from mouse to elephant, not omitting man.

This volume, and the subsequent ones that are promised to result from more years of Sigma Xi lectures, will be considered important contributions to understanding the progress of science. After being read, they will do important reference shelf service.

WATSON DAVIS

DON'T WORRY[1]

"THIS book is written for and about normal people—people who can lay the foundations of their own emotional discomforts, nurture them to inconvenient intensity and learn with ease to control them." In other words, it is for and about the worrier who, in spite of his mental discomforts, is not regarded as psychotic.

The author evidently aims to aid those of his readers who are worriers. Having had much practise in helping and curing worriers, as numerous remarks in the book indicate, he approaches the subject from the point of view of the healer as much as from that of the scientist He begins by assuring his readers that it is the exceptionally intelligent who worry, and that it is modern civilization that causes them to worry. Consequently the worrier first is flattered and then is provided with an excuse for his condition Probably only a small fraction of worriers will question these doubtful, if flattering and consoling, generalizations

At once the author proceeds to explain the process of becoming a worrier and the method of escaping from being a worrier. Passing lightly over possible physical and experiential causes, he maintains that worrying is the result of learning to worry by practice, and that, consequently, the remedy is to unlearn to worry by ceasing to practice worrying This bald statement does not do justice to the sound counsel given by the author to those who worry Yet the essence of his thesis is· "Worry is psychological Psychological conditions are learned. Learning requires practice. Forgetting operates on everything learned. Practice prevents forgetting."

The discussions of common characteristics of worriers and of the interrelations of the emotions and the physiological processes will find a response in the minds of most readers who belong to this afflicted class Case histories of those whom the author has helped or cured illustrate the points made and inspire a hopeful outlook The discussions of methods for correcting bad mental habits and of some "practice procedures" will be helpful, even if they are not profound, the discussion of fears is more fundamental but will not be so readily appreciated by the scientifically immature. The style of writing, consisting very largely of slightly telescoped simple declarative sentences, as illustrated in the quotation above, is somewhat tiring, but the book is sane and deserves a wide circulation among the unhappy victims of worry.

F. R. M.

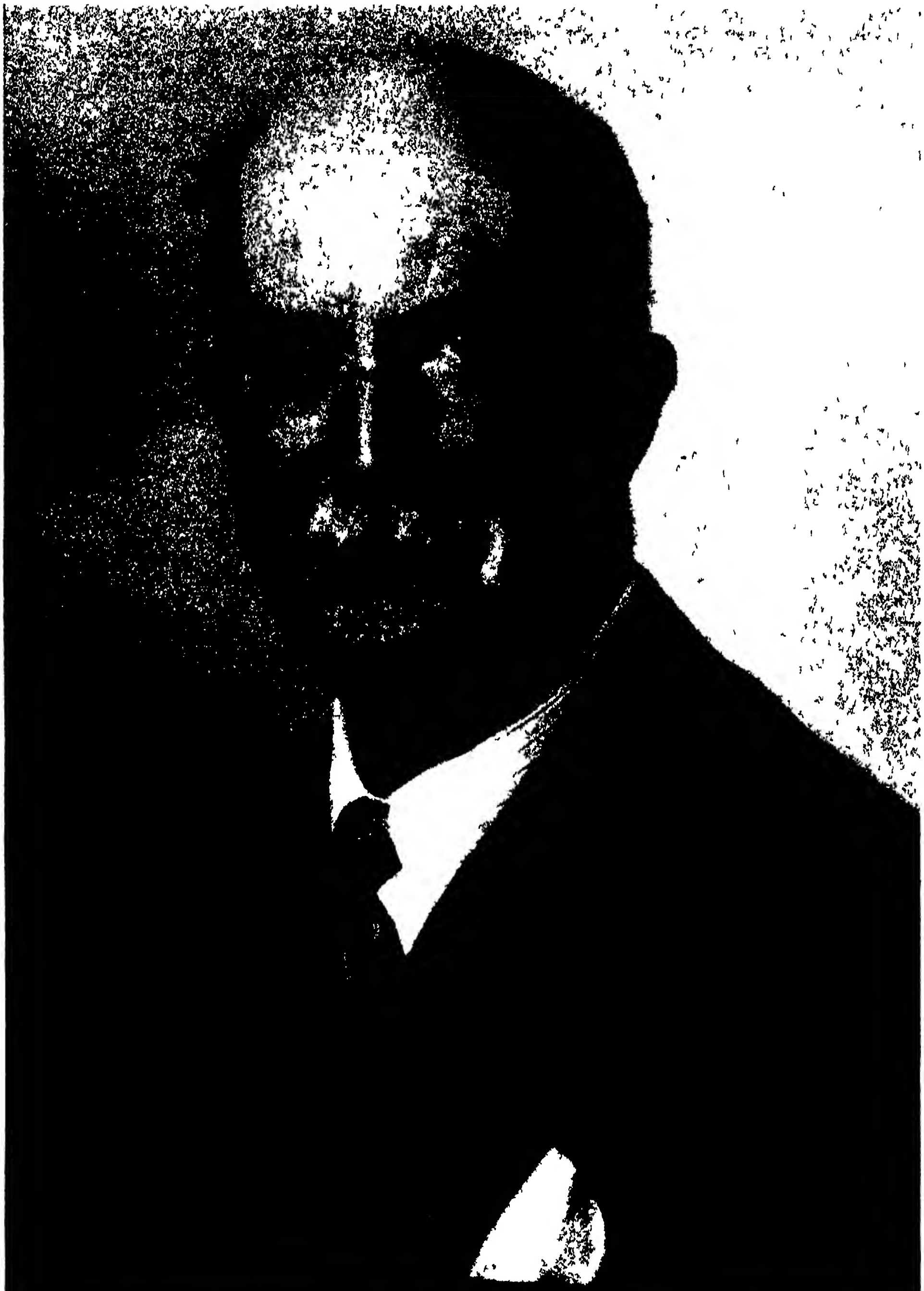
[1] *In the Name of Common Sense.* By Matthew N. Chappell. 192 pp. $1.75. Macmillan Company

ABOUT BIRDS[1]

THIS is a book preeminently notable for its very fine photographic illustrations and for the fact that it does not follow the well-worn path of identification manuals. After an introductory chapter entitled "Why Know Birds?" it takes up the following broad topics, the illustrative cases of which are largely culled from the author's own experience in Nebraska, Illinois, New York and California—the homes and home life of birds up to the time the young are able to care for themselves, the food and feeding methods of birds, the kinds of feathers and their replacement, the migrations of birds, protective coloration and defense actions of birds, the general features of bird classification, the social parasitism of the cowbird and a concluding chapter on how to know the names of birds, how to attract them and how to study their habits The simplicity of the treatment throughout is evidently a plan on the author's part to make the book appealing and useful to a wide audience of beginners in bird study. In this plan he has been successful

H. FRIEDMANN

[1] *Birds.* By Gayle Pickwell. Illustrated. xvi + 252 pp. $3.50. Whittlesey House, McGraw-Hill Book Company.



—Underwood & Underwood

SIR WILLIAM BRAGG

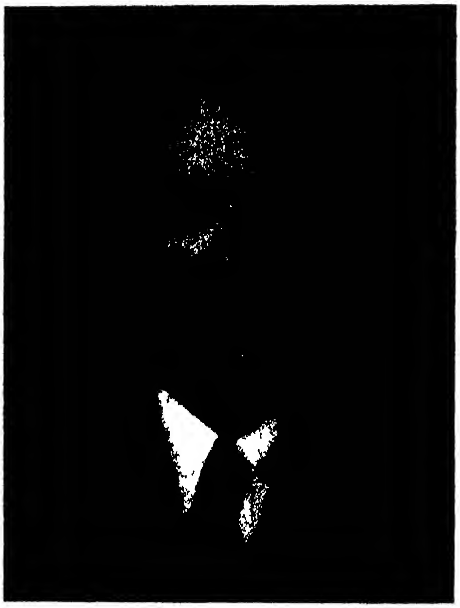
RECIPIENT OF THE JOHN J. CARTY MEDAL, WHO DELIVERED THE PILGRIM TRUST LECTURE BEFORE THE NATIONAL ACADEMY OF SCIENCES ON "HISTORY IN THE ARCHIVES OF THE ROYAL SOCIETY."

THE PROGRESS OF SCIENCE

MEDALLISTS OF THE NATIONAL ACADEMY OF SCIENCES

At the seventy-sixth meeting of the National Academy of Sciences, held this year on April 24, 25 and 26 in Washington, four medals were presented to scientists for noteworthy contributions to science Each medal was awarded on recommendation by the committee appointed to administer the special fund responsible for the medal At present there are eleven trust funds, controlled by the academy, the income from which defrays the expenses connected with the awards of medals in specified fields of science, several of these funds provide honoraria in addition to the medals The names of the medals from these trust funds and the branches of science designated therein are Agassiz Medal, oceanography (17 awards have been made from this fund), Barnard Medal, physics and astronomy (7 awards), Carty Medal and honorarium, any field of science coming within the scope of the charter of the academy (3 awards), Comstock Prize award, electricity, magnetism and radiant energy (6 awards), J Lawrence Smith Medal, meteoric bodies (2 awards), Thompson Medal and honorarium, geology and paleontology (10 awards), Walcott Medal and honorarium, paleontology of Pre-Cambrian and of Cambrian (1 award), Watson Medal, astronomy (10 awards), Hartley Welfare Medal, application of science to public welfare (16 awards) This list shows clearly that the academy is restricted, by virtue of the terms of gift in each trust fund, to definite fields of science in which it may honor investigators for meritorious work These fields and the number of medals awarded in each field are astronomy and astrophysics, 35, physics, 13, meteorites, 2, geology, 4; paleontology, 14; zoology, 13, oceanography, 17, engineering, 1, application of science to the public welfare, 16 The first medal was awarded in 1886, since then the academy has made 113 medal awards During the years 1886 to 1912, inclusive (27 years), sixteen medals were presented, approximately one medal every other year, from 1913 to April, 1939 (27 years), 97 medals were awarded, approximately four per year.

The membership of the academy is divided into eleven sections, representing different fields of research in science The distribution, among these sections, of academy medallists who are now academy members is as follows· mathematics, 0, astronomy, 10, physics, 4; engineering, 1, chemistry, 1, geology and paleontology, 4, botany, 0; zoology, 4, physiology and biochemistry, 0, pathology and bacteriology, 0, anthropology and psychology, 0 In the sections of engineering and of chemistry, the awards were made for applications of science to the public welfare rather than for special contributions to these fields of research The data show that in seven of the eleven sections little, if any, provision has been made in the existing trust funds for the award of medals to workers in the fields represented by these sections This situation indicates a lack of equality of treatment with respect to a large number of academy members and others in certain branches of research work in science The academy is powerless to change the situation, the remedy lies in the establishment of additional trust funds that shall include the fields, now neglected, either specifically or in such form that it will be possible for the academy to honor a worker in any field of science by the award of a medal for noteworthy accomplishment Experience has shown that a trust fund which imposes severe limitations on the awards made from it may not accomplish its purpose so well as one in



DR HARALD U. SVERDRUP

which the conditions of award are less strictly prescribed and a greater degree of freedom is allowed the trust fund committee in selection of a candidate for the honor.

Each medal is presented by the president of the academy to the recipient at the time of the annual dinner Preceding the formal presentation of the medals, the president reports upon the status of the academy and reviews briefly its activities and accomplishments during the year Following his address, he calls upon the chairman or member of the trust fund committee that recommended the award of the medal to state the reasons that led the committee to select the candidate for the honor. The president then, on behalf of the academy, presents the medal to the recipient, who, in turn, replies briefly in words of appreciation for the honor and refers to the research work that influenced the committee in its decision.

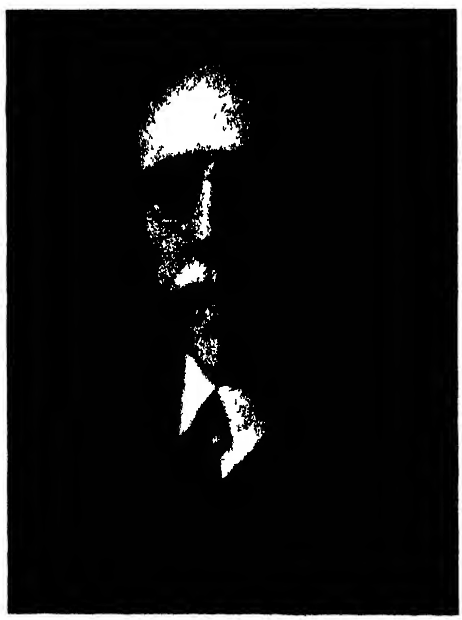
The Agassiz Medal for Oceanography was awarded to Harald Ulrik Sverdrup, director of the Scripps Institution of Oceanography, of the University of California, at La Jolla, California, and professor of geophysics in the Christian Michelson Institute of Bergen, Norway, for his personal oceanographic explorations in Arctic regions and his numerous contributions to physical oceanography and the interrelations between the sea and the atmosphere The presentation address was made by Dr T Wayland Vaughan, chairman of the Agassiz Fund Committee at the time the award was recommended to the academy Dr Vaughan referred to the oceanographic work of Dr. Sverdrup in the Arctic regions, emphasizing especially the results obtained by Dr. Sverdrup from 1918 to 1920 and 1922 to 1925 aboard the vessel *Maud* under Amundsen's general direction, and also his important contributions, theoretical and practical, to dynamical oceanography and meteorology, and to the mechanics of the movements of ocean waters In reply Dr Sverdrup expressed gratitude for the medal from the National Academy of Sciences, he appreciated the honor especially because from his early days he has been associated with American institutions, in particular the Carnegie Institution of Washington, and has many friends in this country Through his connection with the Scripps Institution of Oceanography he now has the opportunity, long desired, to do oceanographic work in part of the Pacific Ocean, which is a vast field for investigation He suggested that it would be fitting to honor the memory of Alexander Agassiz by organization of a large-scale Alexander Agassiz Expedition for exploration of the Pacific Ocean The value of such an expedition would be very great

The John J Carty Medal and Honorarium for the Advancement of Science, consisting of a gold medal, bronze replica, certificate and $3,000 in cash was awarded to Sir William Bragg, director of the Royal Institution and of the Davy-Faraday Research Laboratory and pres-

ident of the Royal Society of London, England, for his fundamental work in x-ray crystal analysis and the development of a new method and approach to this field of the atomic structure of crystals His studies have given birth to a new tool that is bringing to light important facts regarding such complex structures as the larger organic molecules Dr Frank B. Jewett, chairman of the John J Carty Fund committee, in his presentation address reviewed briefly the work of Sir William as an investigator, an able and inspiring teacher and a leader in guiding and advising with respect to matters of applied science Following Dr Jewett, Dr. Arthur H Compton spoke in greater detail of the work of Sir William and of his many contributions to science and to the diffusion of knowledge of the achievements of science and of its methods In reply, Sir William voiced sincere appreciation of the honor, but stressed the important part played by his son and others in the work specified in the award of the John J Carty Medal

The Daniel Giraud Elliot Medal for 1933 and accompanying Honorarium of $200 was awarded to Richard Swann Lull, of the Peabody Museum of Natural History, Yale University, New Haven, Connecticut, in recognition of his work entitled "A Revision of the Ceratopsia or Horned Dinosaurs," published in the Memoirs of the Peabody Museum of Natural History Dr W B Scott, on behalf of the committee on the Daniel Giraud Elliot Fund, made the presentation address and referred to Dr Lull's Monograph on the Horned Dinosaurs as a very comprehensive and thorough piece of work In this monograph the material scattered through various museums in the United States and Canada is described in detail, together with an account of the habitats and manner of life of these great reptiles The treatise closes with a discussion of the evolution of this Upper Cretaceous group in which the great quantity of material is marshalled in an orderly way and their mutual relations are admirably discussed In response Dr. Lull expressed appreciation of the medal award by quoting from a note recently received from Japan. "It is with 'the greatest honor and unutterable throb of heart I feel in offering you this word of thanks'" Dr. Lull referred to the proposal made many years ago by Othniel C. Marsh, of Yale University, to prepare a series of monographs on the very large collections of fossil vertebrates gathered under his direction Of these memoirs Dr. Marsh prepared two, Dr H F. Osborn, several others, and Dr Lull, the one on Ceratopsia, published in 1906 The 1934 monograph on the same group assembles the knowledge gained by many investigators from discoveries made since 1906

The Daniel Giraud Elliot Medal for 1934 and accompanying Honorarium of $200 was awarded to Theophilus Shickel Painter, of the University of Texas,



PROFESSOR RICHARD S LULL

PROFESSOR THEOPHILUS S PAINTER

Austin, Texas, in recognition of his work on the chromosomes of the salivary glands in Drosophila in relation to the problems of mutations and genetics, published in *Genetics* and the *Journal of Heredity* in 1934 In his presentation speech Dr Ross G Harrison, chairman of the committee on the Daniel Giraud Elliot Fund, reviewed the work by Dr Painter on the chromosomes in the salivary gland cells of Drosophila in which the constancy of the band pattern in corresponding chromosomes and the difference between the several chromosomes with regard to this pattern was discovered. Dr. Painter showed that these bands mark the positions of the genes in the same order as had been postulated from the cross-over studies by T. H Morgan and his school This discovery has greatly facilitated the study of the relation between chromosome pattern and hereditary processes and has added much to our knowledge of the positions of the submicroscopic gene elements in chromosomes In reply Dr. Painter voiced his appreciation of the honor bestowed on him in the award of this medal and attributed his success in correlating the position of gene loci with definite bands along salivary gland chromosomes to three fortunate circumstances Under Dr Muller he had plotted the position of gene loci in metaphase chromosomes and realized then that the large persistent spireme threads of salivary glands might furnish promising results By use of the stain, aceto-carmine, on crushed mounts he was able to study the salivary chromosomes satisfactorily Fortunately, in the research institution in which he was then working enough of these broken chromosomes, that had been analyzed genetically, were available for study and on them the observations were made that allowed inferences to be drawn regarding the positions of the genes relative to the bands of the chromosomes

F E WRIGHT,
Home Secretary

REFLECTIONS ON THE MILWAUKEE MEETING

THE programs of the Milwaukee meeting (June 19 to 24) of the American Association for the Advancement of Science illustrate the great variety of interests of scientists and the corresponding wide differences in their reactions to an environment.

To geologists the area that includes Milwaukee is one that has had a varied and interesting history for 2,000 million years In the early part of this period there were convulsions and intrusions and extrusions of liquid magmas from which geologic agencies eventually produced rich deposits of iron ore and copper (The geologists have excursions to these regions) In later periods sediments and deposits of lime accumulated

while the waters of shallow seas repeatedly rolled over this region Only yesterday, as it were, great sheets of ice pushed irresistibly down from the north and produced fertile soil and numerous deposits of gravel. To geographers the area is one of precious natural resources to be preserved They have organized a symposium on soil conservation and land utilization in the region

To biologists Wisconsin and neighboring states have a varied natural flora and fauna and offer unsurpassed opportunities for the production of plants and animals useful to civilized man A symposium and many other papers are devoted to discussions in this field

To anthropologists the area in which Milwaukee is located has been the home of men for several thousand years, possibly since shortly after the last retreat of glacial ice The numerous mounds of these peoples reveal a fascinating story of their approaches toward civilization which is only now being read

To the members of the Section on the Social and Economic Sciences Milwaukee is a great center of industry and social organization which is notable for the high standards that have been maintained in its government Unremembered are the great events of its geological history, important as they may have been in producing the present natural wealth of the region Forgotten are the prehistoric men who once roamed its prairies and forests, as are the Indians who were disputing its possession with white men only a century ago Thus to every group of scientists a geographical area is entirely different

Milwaukee, from an Indian word meaning "good lands," was first visited by white men in 1673 when Father Marquette and Louis Joliet, returning from a voyage down the Mississippi River, skirted the left shores of Lake Michigan It is believed that La Salle stopped at the site of Milwaukee in 1679, which he referred to as "Millioke " No Europeans, except possibly French voyageurs and fur traders, traversed the western shores of Lake Michigan for nearly a century until the Englishman Alexander Henry

—*Milwaukee Public Museum Photo*

MILWAUKEE PUBLIC MUSEUM AND LIBRARY BUILDING

—*Milwaukee Public Museum Photo*

THE MILWAUKEE COUNTY GENERAL HOSPITAL

visited the site of Milwaukee in 1760 In 1795 Jacques Vieau established a permanent post at Milwaukee for the North-Western Fur Company, which was maintained until it was succeeded by Astor's American Fur Company in 1820

Colonists began to arrive in the neighborhood of Milwaukee in 1833, the year in which Morgan L Martin surveyed the harbor The first saw-mill was constructed in 1834, following which three villages sprang up, Juneautown, Kilbourntown and Walker's Point In 1846 they were united and incorporated as the City of Milwaukee Milwaukee became a center of the lumber industry and for several decades was the metropolis of the Great Lakes The first mayor of the city was Solomon Juneau. For 40 years the Fire and Marine Insurance Bank, which was opened in 1839, was one of the strongest and most favorably known banks west of the Allegheny Mountains

Milwaukee has been an intelligent and progressive community from its earliest days On July 14, 1836, its first newspaper, *The Milwaukee Advertiser*, began publication Its first public school was opened in 1839 Its first telegraph line, connecting the city with Chicago, was put into operation in 1849, and its first railway in 1856 Milwaukee owes much to the immigrants who began to arrive from Germany in large numbers in 1840 In 1900 about 72 per cent of the population of Milwaukee was of either German birth or the children of German-born parents Reflection on the amazing changes that have taken place in Milwaukee and surrounding territory within a century makes one wonder whether there will be similar changes during the next century As great as they have been, they have not exceeded those that have taken place in science This has been a rapidly changing world

F R Moulton

THE WHITNEY WING OF THE AMERICAN MUSEUM OF NATURAL HISTORY

On June 6, 1939, the American Museum of Natural History, New York, dedicated a new wing of its structure devoted wholly to the Department of Birds In the presence of members of the Whitney family and 400 guests, addresses signalizing the event were made by President F. Trubee Davison, Mr Cornelius Vanderbilt Whitney, in the double capacity of trustee of the museum and representative of the three generations of his family which have befriended the institution, Dr Leonard C. Sanford, a trustee whose particular interest is ornithology; Dr Frank M Chapman, for more than fifty years head of the Department of Birds, and Dr Robert Cushman Murphy, curator of oceanic birds

The building was given jointly by the late Mr Harry Payne Whitney and the City of New York It is a memorial to Mr William C Whitney, Secretary of the Navy during the first administration of President Cleveland and patron of American Museum researches relating to fossil horses and other Tertiary mammals After the death of the donor, in 1930, Mrs Harry Payne Whitney and their three children, Mr C V Whitney, Mrs G Macculloch Miller and Mrs Barklie McKee Henry, continued to support development of the equipment, collections and exhibits of the department, their greatest single gift being the 280,000 study skins of birds amassed by the late Lord Rothschild and formerly housed in his Zoological Museum at Tring, Hertfordshire.

The Whitney Wing is a building of eight stories, three of which are devoted in whole or in part to public exhibition Six office and laboratory floors are fitted with steel cases for the safe storage of the world's most comprehensive collec-

SEVEN OF THE HABITAT GROUPS IN WHITNEY MEMORIAL HALL

AND THE DOME OF THE SKY WHICH APPEARS TO RISE FROM THE COMMON HORIZON OF THE SEPARATE EXHIBITS.

A SCENE ON THE FAR-FAMED CHINCHA ISLANDS IN THE BAY OF PISCO, PERU

CONSPICUOUS ON THESE GUANO ISLANDS ARE THE THREE MOST IMPORTANT GUANO BIRDS, NAMELY THE PERUVIAN CORMORANT ("THE MOST VALUABLE BIRD IN THE WORLD"), THE BOOBY (ON THE CLIFFS), AND THE VERY LARGE BROWN PELICAN OF THE HUMBOLDT CURRENT

A SCENE ON JAMES ISLAND, LOOKING TOWARD ALBEMARLE

THE MOST IMPORTANT BIRDS IN THIS EXHIBIT OF GALÁPAGOS BIRD LIFE, FROM A BIOLOGICAL POINT OF VIEW, ARE 9 SPECIES OF THE FAMOUS "GALÁPAGOS FINCHES," WHICH ARE CREDITED WITH HAVING MUCH TO DO WITH DARWIN'S ORIGINAL IDEAS ON THE PRINCIPLE OF NATURAL SELECTION AS AN EXPLANATION OF EVOLUTIONARY CHANGE

tion of birds, which now numbers approximately 750,000 specimens. The greater part of the top floor is given over to modern aviary space in which the behavior and heredity of living birds may be studied Moisture and humidity control, sun-lamp illumination and other modern experimental auxiliaries are here provided The broad central corridor of the fourth floor takes the form of a well-lighted art gallery, available for both permanent and temporary showings of field studies and finished paintings, prints and sculpture relating to birds Its present installation comprises the museum's historical series of sketches by Louis Agassiz Fuertes, illustrations by Joseph Wolf executed for the lavish ornithological monographs of Dr Daniel Giraud Elliot, several paintings by Audubon and a group of oils and water-colors by Courtenay Brandreth The first floor is a hall of 16 alcoves, to be developed as a diagrammatic exhibit of the biology of birds and other animals A provisional layout in four of these alcoves was ready for the opening on June 6

Whitney Memorial Hall, on the second and main exhibition floor of the wing, comprises a diorama of the Pacific Ocean and its far-flung islands Eighteen cases for habitat groups surround an oval floor space, on the midline of which are bronze busts of William C Whitney (1841–1904) and Harry Payne Whitney (1872–1930), by Augustus St Gaudens and Jo Davidson, respectively The walls of two terminal alcoves carry mural maps which function both as decoration and a means of orientation for visitors, together with dedicatory inscriptions The ceiling is a sky-dome, illuminated from hidden sources, which appears to rise from the common horizon on the backgrounds of the habitat groups. The painting throughout is the work of Francis Lee Jaques, of the museum staff

Whitney Memorial Hall is one of the results of the Whitney South Sea Expedition of the American Museum, which since 1920 has carried on continuous or-

SHIP–FOLLOWERS

A FEBRUARY (MID SUMMER) DAY ON THE OCEAN SOUTHEAST OF NEW ZEALAND, WITH PETRELS AND ALBATROSSES OF VARIOUS SPECIES KEEPING COMPANY WITH SAILING VESSELS IN THE BACKGROUND IS THE SCHOONER "FRANCE," OPERATED BY THE AMERICAN MUSEUM FOR A DECADE IN THE SOUTH PACIFIC

BIRDS OF THE SOUTH SEA ATOLL

DETAIL OF THE HAO ISLAND GROUP, IN THE TUAMOTU ARCHIPELAGO, WITH MAN-O'-WAR BIRDS AND VARIOUS SPECIES OF TERNS FACING THE SOUTHEAST TRADE WIND

nithological researches among the Pacific islands with funds provided by Mr. Harry Payne Whitney

The purpose of this hall is to show the bird life of the Pacific Ocean and its islands The scope of the exhibits extends from sub-Antarctic latitudes in the New Zealand region northward to islands near Hawaii, at the southern border of the north temperate zone and from the coast of Peru westward to Australia, New Guinea and the Philippines A wide range of physiography, climate, vegetation and bird life is thus illustrated, and, in conjunction with the mural maps, an effort has been made to show the effect of climatic zones, prevailing winds, ocean currents and the relative distances of island groups from the continental masses of the Old World and America, to which they owe their fauna

Exhibits thus far installed are entitled "Ship-followers," "Samoa," "Tuamotu," "Marquesas," "Peruvian Guano Islands," "Galápagos," "Hawaii" and "Laysan" Future habitat groups will similarly represent the bird life of the Solomon Islands, Fiji, Australian Barrier Reef, New Guinea, an Antarctic outlier of New Zealand and other Pacific localities In addition to the patronage given this hall by Mrs Whitney, her son and two daughters, generous supplementary support of field work and group construction has come from several friends of the late Mr Whitney or the museum, including Messrs Templeton Crocker, Andrew G C Sage, Henry W Sage and Dr Sanford Two of Mr Crocker's cruises in his schooner yacht *Zaca* are, indeed, responsible for the selection of sites and the making of field studies for seven of the eight groups now completed

AIRPLANE CRASH AT THE LICK OBSERVATORY

On Sunday evening, May 21, 1939, at about 7 11 P M , an Army airplane collided with the main building of the Lick Observatory The plane was of the "attack" type and is said to have been capable of a speed of 210 miles an hour, it was piloted by Lieutenant Richard F Lorenz and carried Private W E Scott as a passenger Both occupants were instantly killed Mount Hamilton, on which the observatory stands, was enveloped in clouds at the time The plane belonged at March Field near Riverside and was returning there from Hamilton Field near San Francisco, when it struck us Mount Hamilton is in a direct line between the two stations, and this line bears southeast, so that the plane was on its course at the time

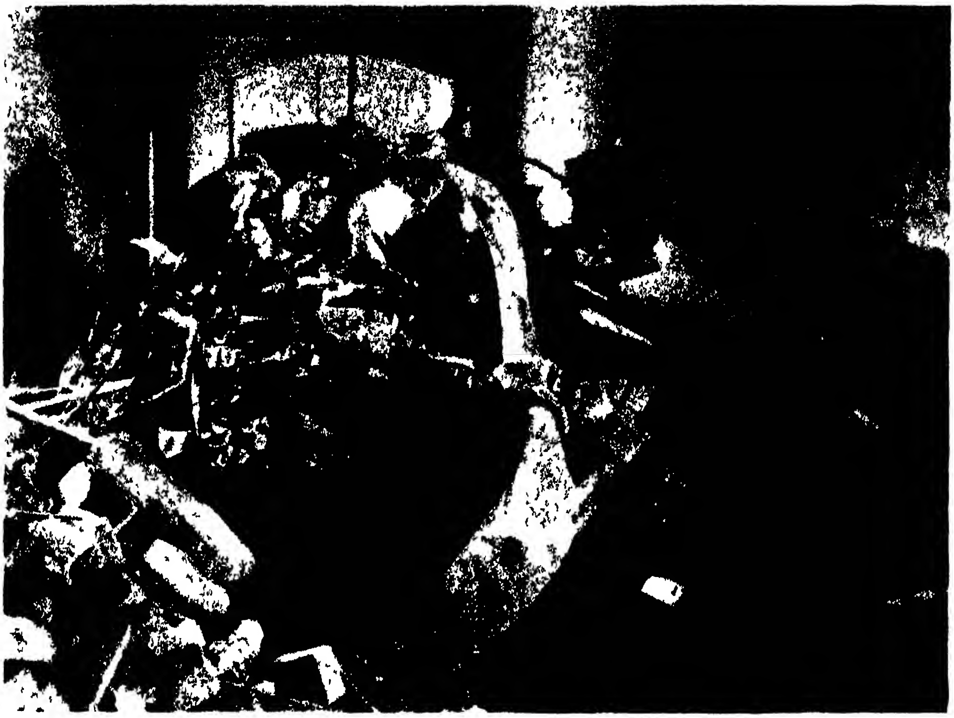
The plane struck the west façade of the building, about fifty feet north of the principal entrance, and crashed through two offices into the main observatory corridor, where it was stopped by the reinforced concrete wall which forms the east side of the building The direction of motion within the building was, as nearly as could be determined, southeast In its course the plane penetrated two brick walls, one 20 inches and the other 13 inches in thickness, and went diagonally through a dividing wall separating the two offices

The engine and greater part of the fuselage were deposited in the offices and corridor, with bricks and mortar from the demolished walls

Fig 1 shows the area of entry The protruding fragment is the right wing Fig 2 is a view of the main observatory corridor looking toward the north, and Fig 3 is one from the other side of the wreckage, looking south The pile of débris—plane, bricks and mortar—was 40 feet long and about 9 feet high at the crest It required two or three days to clear this material away and to wall off the damaged section of the building for

PLACE WHERE PLANE PIERCED WEST FAÇADE OF THE OBSERVATORY

WRECKAGE IN MAIN CORRIDOR, LOOKING NORTH



MOTOR AND ACCOMPANYING WRECKAGE IN MAIN CORRIDOR, LOOKING SOUTH

the purpose of excluding dust After that it was possible again to take up the normal activities of the observatory

When we turn from the contemplation of the tragic consequences of the accident it is possible to derive some satisfaction from the circumstance that little or no damage was done to the scientific equipment or to photographic and other records of the observatory The material loss is, of course, considerable, but it is believed that this will not prevent speedy rehabilitation of all the observatory's facilities

Records of the effect of the impact of the plane are given by our seismographs and self-recording barometers Of each of these instruments we have two types, but at the moment only one seismogram and one barogram are available for study

The seismogram, which is from the Wiechert machine, has been examined by Dr Jeffers and myself. The record of the disturbance appears, to the eye, as a small spot on both the west-east and north-south tracings Examined with a glass the spots are readily seen to be minute "shock" records of about two or two and a half seconds' duration The initial movement is in each case about 1 mm, followed by a rapid swing to a point 4 mm on the opposite side of the zero point, subsequent oscillations are not readily distinguishable, but the trace is broad during the remainder of the short interval of time above indicated After allowing for the magnifying factor of the instrument, and otherwise reducing the data to simple terms, we find the following facts There was a sudden displacement of the earth, at the site of the seismograph, toward the southeast, about 1/57 mm in amount This was followed by a reverse movement totaling approximately 1/41 mm, or 001 inch, after which the vibration gradually died out The

initial displacement corresponds, as would be expected, with the direction of flight of the airplane, that is to say from northwest to southeast The seismograph is distant about 120 feet (36 meters) east-north-east from where the plane struck, so it is clear that a very considerable part of the mountain top was set in motion by the impact The time of the initial displacement was 10 minutes and 59 seconds past 7 P M, Pacific Standard Time This figure is regarded as possibly subject to an error of a second or two, it furnishes the most reliable time of the collision now available

The barogram to which reference has been made is that provided by the Draper mercury-weight self-recording barometer There was a sharp barometric rise of about 013 inch and an immediate recovery In view of the weight of the moving parts of this barometer and the short duration of the disturbance, it is probable that the actual rise in pressure was considerably in excess of the above amount It should be stated that the barometer is situated in the observatory corridor and that some increase in pressure would be expected as a consequence of the sudden entry of the plane into the building and of the falling inward of the walls

At the time of the accident there was one person in the building and some half dozen in the immediate vicinity Every one remarked the roar of the approaching plane, which was obscured by the cloud in which the mountain was enveloped The noise of the impact seems to have been effectively smothered within the building, and the single occupant mentioned did not at first realize that the building had been struck The sudden silence following the roar of the engine indicated to all that the plane had "crashed," but, until the opening in the wall was discovered and the mutilated machine found in the observatory corridor, it was believed that the accident had occurred somewhere on the mountain side

It may be worth relating that two visitors were just arriving at the observatory when the plane flashed across their path and buried itself in the building Until matters were explained to them they apparently had no very clear idea of the meaning of it all Possibly they regarded it as a mere matter of observatory routine

As will be realized, the situation precipitated by the collision was a very serious one Within a few seconds of time a great mass of gasoline-soaked wreckage established itself within a far-from-fire-proof building The cool and efficient manner in which the young men and women who were first on the scene adopted precautions against explosion and fire are deserving of the highest commendation Their prompt and efficient action undoubtedly saved the observatory from a major catastrophe

W H WRIGHT

A REMARKABLE NEW SAFETY GLASS

ON the last day of March, in the lecture hall of the Franklin Institute, Philadelphia, a new, modern, high-test safety glass was given its first public exhibition, the audience consisting of high officials of the chemical and automotive industries They viewed a number of convincing demonstrations of the valuable properties of the new safety glass

In the early days of the automobile its speed was so low that there was little use for glass as windshields, but, as speeds increased and cars were used in all weather they came to resemble a sort of traveling show-case, with glass on all sides This glass was a constant menace, for in case of accident the flying fragments were responsible for a large majority of the injuries sustained

It was an accident which was respon-

COMPARATIVE EFFECTS OF A STANDARD BLOW AT WINTER TEMPERATURE

sible for the germ of the idea which has grown into safety glass In 1903, Edouard Benedictus, a French chemist, reached for a bottle on a shelf in his laboratory He knocked another bottle to the floor When he started to sweep up the pieces, he was startled to find that the bottle, although shattered, retained its shape It had held collodion The ether and alcohol had evaporated and the celluloid coating held the fragments together Benedictus did not immediately realize the application that might be made of his discovery, nor did he perform any experiments with coated glass until he witnessed a motor accident in which a young woman was badly cut

From the earliest safety glass to that of 1939, the fundamental principle has been the manufacture of a "sandwich," with a plastic filling between two sheets of glass This glass provided protection from flying stones or other objects outside the car, and the danger of injury from murderous particles of glass was greatly reduced

The first safety glass filler was a cellulose nitrate plastic, but this, it soon was learned, often became discolored from the actinic rays of the sun which penetrated the glass This difficulty was solved by adding iron to the glass so that the harmful rays would be absorbed

The second step in the development of safety glass was the substitution of cellulose acetate for cellulose nitrate This material did not discolor in sunlight, because the acetate film is transparent to the actinic rays of the sun However, this material required careful edge sealing to prevent moisture from getting in and to avoid evaporation of the plasticizer Otherwise there would be cracks and separation at the edges

One major disadvantage which the acetate safety glass shared with the nitrate glass was their tendency to lose toughness and strength at temperatures which are often met with in winter driving When the temperatures of these plastics were below 20° F they became brittle and lost almost all their safety-glass properties. Since the low temperatures of winter are often accompanied by increased driving hazards, research during the past five years has been directed toward the discovery of a new plastic film not having this defect

As the result of this research the discovery of polyvinyl acetal resin brought the industry much closer to an ideal safety glass It is this material that is used as a bond in the new high-test safety glass which was introduced at the Franklin Institute Not only is the new glass much stronger than the old at ordinary temperatures, but, even when cooled to as low as 10° below zero F, it retains its safety features, indicating that protection is assured even under severe winter driving conditions

Moreover, this new substance does not become discolored nor does it require special sealing on the edges when it is cut into special shapes from standard pieces Since the glass part of the sandwich is plate, the result is a product of fine optical clearness, without waviness or imperfections

Polyvinyl acetal resin is a rubbery thermoplastic material A sheet a few thousandths of an inch thick is placed between two pieces of glass When heated it softens to form a plastic bond, with perfect adhesion between all surfaces While milky before being inserted into the "sandwich," the plastic sheet becomes entirely transparent during the processing

The plastic film itself has remarkable properties In the form of a swing it will support the weight of a man The shock of a 15-pound bowling ball hurled upon an outstretched diaphragm is absorbed by the film These shock absorption qualities of the resin filler are also retained by the safety glass made from it Even though this glass is many times more resistant to shocks, sudden impact is not likely to result in fractured skulls, concussions or lacerations

A sheet of the new high-test safety glass may be pounded until the glass is completely broken and it may then be rolled up like a rug without scattering the fragments of broken glass

NICOL H SMITH

DEMONSTRATION OF ELASTICITY

AFTER THIS BLOW FROM A BOWLING BALL THE MEMBRANE, 0 015 INCHES THICK, RETURNS TO ITS ORIGINAL SHAPE

DEMONSTRATION OF STRENGTH

198 POUNDS SUPPORTED BY A STRIP OF MEMBRANE EIGHT INCHES WIDE.

THIS COMPLEX WORLD—NICKEL

NICKEL is not one of the principal elements of which the earth is composed In the rocks which make up its outer layers, there is 2,300 times as much oxygen, 1,400 times as much silicon, 400 times as much aluminum, and even 250 times as much iron Nor is nickel an element that is a principal food of plants or animals, either uncombined with other elements or in compounds If it is necessary at all for living organisms, it is required in only very minute quantities It is not even used for jewelry and ornaments Yet threads of nickel run all through the varied fabrics of civilization, and on its slender strands hang weighty problems of industry, economics and international relations

About fifty years ago it was found that the addition of even a few per cent of nickel to steel makes an alloy of very remarkable properties The most important of the properties of nickel-steel alloys is that they are very much stronger and tougher than ordinary steel Another is that the alloys, especially those containing more than 5 per cent of nickel, are stainless and acid-resisting Naturally the proportions of the metals that should be used to obtain alloys of specified properties and the methods of producing them were learned only after a large amount of experimentation Moreover, until well within the present century nickel was not available in large quantities, and that which was available was costly It was only after the development of the great nickel mines near Sudbury, Ontario, and after improving the methods of refining it, that this metal became so abundant and cheap that it could be used extensively for industrial purposes

Recently the railways have been under severe pressure, about half of those in the country being virtually bankrupt In order to reduce operating costs the capacities of freight cars have been steadily increased, longer trains have been hauled and greater average speeds have been attained. Now lighter equipment of a given capacity is being introduced by the use of nickel-steel alloys An immediate result is that the weight of the cars for a given load is reduced by about 17 per cent, and a whole chain of consequences follows—engineering, maintenance, employment, economic, financial For a given amount of traffic, right of way and equipment will require less maintenance, less steel will be used, less coal will be burned, longer trains will be hauled, and for all these reasons employment will be reduced

The value of machine tools and machinery requiring strength and durability produced annually in this country is of the order of two billion dollars The uses of nickel-steel alloys in these fields, especially in high-speed machine tools, are of the highest importance The consequences in reducing costs of an endless variety of manufactured products, and therefore increasing their consumption, and in requiring less man power, modify every aspect of our social and economic and, indirectly, political order The same thing is true of the consumption of nickel in the production of stainless and acid-resisting steels for uses in the chemical industries

Nowadays nearly every discussion eventually leads to the question of war, as this one does Without nickel guns could not be produced that would have ranges of many miles, naval vessels (and other ships) would be heavier and their armor more easily pierced, airplanes would have less carrying power—war of offense and defense would be entirely different In a very long war control of the sources of nickel might be a deciding factor Over 90 per cent. of nickel is produced in Sudbury, Canada, and a large part of the remainder in the island of New Caledonia, which is under French control

F. R M

philosophy. Our minds bother us Our most serious troubles are mental, and many problems of practical life and of science would be simplified if the mind were given a holiday. Many people do this more or less deliberately with results not always fortunate. Some objective psychologists have done their best to lay the ghost, but it will not down. It does not do any good to try to solve a difficult problem by ignoring the troublesome factors or by identifying mind with every sort of nervous action, with adaptation or with all totalizing or integrative functions. And panpsychism is a speculative excursion of more interest to metaphysics than to science.

For our present purpose the traditional usage is adequate My mind is my awareness of what is going on. I shall not try to define this; I don't have to, because I experience it, and so do you, but I do have to accept it as a natural phenomenon, and as a naturalist I can, therefore, claim a legitimate scientific interest in it The possibility of scientific treatment of the subjective has been denied, I know, but this denial is based on erroneous assumptions, that is, on the traditional doctrine that my mind is a ghost and not an organic part of me

The aim of natural science is generalization and the method is a survey and comparison of particular things or events which have come within experience and abstraction from them of some general characteristics common to all of them Science can do nothing with an isolated fact. How, then, can we investigate scientifically anything so intimately personal, so unique and detached, as the idea or the emotion that has just flashed through my mind?

This is the naturalist's dilemma, which is resolved very simply by the transcendentalists, who say there is no problem here because the mind belongs in a spiritual realm which is not bound by the rules of the natural order This is the tradition of the New England Protestant orthodoxy in which I was brought up and of such teaching of psychology and philosophy as was offered in my early schooling. But it does not square with my experience as a neurologist or in the common affairs of adjustment to things and people in the daily routine of life.

Common observation shows—if it shows anything at all about human nature and conduct—that my conscious motives, what I want, what I work for, and my ideas about it, are actually caused by previous events, some of which are conscious and some are unconscious, some inside my own body and some outside. All these are natural events, and no one of them is an isolated event. Even our most intimately private mental experiences have discoverable relationships with other things and events They can, therefore, be investigated scientifically, for the study of relationships is the basic scientific method All that we know about anything is its relationships, in fact, the thing is defined by these relationships This holds for everything in our natural cosmos from electrons to faith, hope and charity

If I make up my mind to sell my house and move my family to a hotel, this decision is the result of countless things that have happened before—changes in the physical and social environment, increase in taxes, the state of my health or perhaps the desire for ready cash to finance a speculation. The relation between these previous events, both the objective and the subjective, and my present motive is a true cause-and-effect sequence by all the rules of scientific evidence that we commonly apply in other fields of inquiry

From the other angle my motive in advertising my house for sale, which is of course a conscious act, is also a real cause of some later events If I find a purchaser and invest the proceeds in a wildcat speculation, the loss of my fortune

affects all the rest of my life and the lives of my children. Here we have a mental or "spiritual" event actually having material consequences, and nobody would challenge it as a cause-and-effect sequence if it were not for a preconception or taboo rooted in mysticism and mythology

It should not be necessary to labor the point that mind and body form an organic unity. We have no experience at all of any mentality apart from bodily organs This is the opinion of the business executive when he pays a large salary to "a man with brains" Here is a case where the popular idea stands up under the most searching scientific criticism better than the sophistries and dogmas of the schoolmen Yet even those of us who are biologically trained are apt to give only lip-service to this sound scientific conclusion. The tradition of the prescientific mythologies is so deeply implanted that we often fail to recognize its influence. Most people still cherish some modern version of those primitive demonolatries which split the human personality up into physical and spiritual components.

But my mind is not something detached or detachable from my body and so capable of dallying at large independently of the rest of me Whatever may be acceptable in theology and metaphysics, the biologist as biologist can not be a dualist, a trinitarian, a hydra or any of the other fabulous chimaeras of our mythologies. All nature as he knows it is an orderly unit, and anything outside of this integrated and law-abiding system of things and events is unnatural and therefore out of reach by the method of natural science. Our present interest is to see how far we can go in the exploration of the mental life without overstepping the boundaries of the natural order

It is obvious that even in the field of medical practice the ghosts of traditional spiritism have not yet been exorcised. The average physician is apt to neglect the mental attitudes of his patients, forgetting Osler's teaching that mental therapy—he called it "faith"—is the most potent remedy of his pharmacopœia Even the surgeon should not neglect it. The late Dr Billings, toward the end of his distinguished career as an internist, underwent a major surgical operation, after which he is reported to have said that every surgeon before being permitted to perform an operation should be required to submit to one himself This, no doubt, is asking too much. Nothing so drastic has ever been tried, except perhaps by the psychoanalysts.

In psychiatry a methodological barrier has been set up between so-called "organic" and "functional" diseases. The treatments required in the two cases are indeed radically different If a toxic goitre is diagnosed as a cause of mental disturbance, the surgeon may effect a cure But our most distressing cases of mental disease are as yet known only symptomatically, that is, as mental disorder Knowing nothing of the colligated bodily disorders, we apply mental therapy, often with gratifying results. Functional disorders may be treated by functional therapy; but where this fails, as alas! it does too often, we are thrown back upon a search for causes, and, as we have seen, the causal complex of any mental process is a web of structure-function relationships which must be seen in its entirety before we can hope for complete understanding The exclusively mentalistic systems of some psychiatries are rooted in transcendental philosophy They have, accordingly, an internal consistency and in some cases good practical results, for our mental life is normally orderly and some of the laws of this order are obvious within the domain of introspective experience alone. Yet this type of medical practice at its best has serious limitations which can not be wholly overcome by the most scrupulous care on the part of the psy-

chiatrist in referring his patients to other specialists for diagnosis and treatment of possible organic complications For the psyche has no existence apart from the soma, and the psychiatrist, like every other physician, must treat his patient as a whole and not some disembodied complex of symptoms.

Do not misunderstand me. It is not recommended that mental therapy be abandoned and replaced by organic therapy That would be a blunder far more serious than the neglect of organic therapy by a psychiatrist Organic therapy and mental therapy must converge upon the patient The practice of mental medicine must employ its own armamentarium of principles and technique which are as different from those of other specialties as surgery is from hydrotherapy. But the psychiatrist as truly as the surgeon must be first a physician and then a specialist This is fortunately now fully appreciated by progressive psychiatrists, as typified, for instance, by Adolf Meyer's psychobiological approach to mental disease.

III

Having now decided that my mind, that is, my awareness, is a vital function, we come to the nub of the question—How is my mentality related with other vital processes, what is the apparatus employed in thinking, and how does it work?

There are two traditional formulations of this problem. First, How does a body make a mind? and, second, How does a mind make a body? These questions in one form or another have been debated for centuries, and we are no nearer the answer to-day than was Democritus or Plato I am convinced that the question formulated in either of these ways, that is, in terms of either traditional materialism or traditional idealism, is insoluble

Those dualistic philosophies which segregate the physical and the spiritual in two parallel but independent and incommensurable realms of being are incompatible with any kind of natural science. And those traditional monistic systems which postulate either matter or mind as the primary or ultimate reality and the other as secondary or even illusory are equally sterile and misleading in the domain of natural science.

Things and their properties, mechanisms and what they do, organs and their functions, human bodies and human experience, can not be divorced in this way. What nature has joined together, let not man by artifice of logical or metaphysical analysis tear asunder. These things do not exist separately To abstract one from the other is to annihilate both Count Korzybski in his "Science and Sanity" has exposed the futility of these elementalistic systems His definition of structure is dynamic, in terms of relations Bodily structure, accordingly, is not one element, its function another, and its mental experience a third, for these can exist and be defined only in their relations one with another and with the surrounding world with which they are in adjustment

Of course, we experience these things differently, for we do not live in a world of pure experience We live relativistically, and our finite experience can not hope to encompass ultimate reality or any of the other absolutes of the metaphysicians. "For now we know in part, and we prophesy in part," and the human mind can not hope ever to attain "that which is perfect" Neither the Apostle Paul nor any other philosopher has ever succeeded in encompassing the infinite within the three-pint capacity of a human brain

If now you demand specific and detailed answers to the questions, first, What are the bodily organs of the mental processes?, and second, Exactly how do these organs operate in the performance of mental work?, the neurologist can

supply a great deal of information about the first topic. The right answer to the second question is that we do not know The knowledge already available about the bodily apparatus employed in mental processes and recent developments of new methods and instruments of precision encourage the hope that this second question is not insoluble

It is possible to find out what parts of the body are actively engaged when we perceive a flash of light, when we are hungry or angry or when we imagine a muscular movement without actually executing it We do not yet know all about any of these processes, but it is a great gain to have identified some of the organs involved and to be able to record quantitative measurements of some of their activities We are beginning to know just where to look for other essential facts.

One general statement may now be made with complete assurance The search for some particular localized organ of consciousness in general or of any particular conscious experience is as futile as was Descartes' identification of the pineal gland as the seat of the soul

If at night I am looking at the sky, recognize one of the stars as our nearest neighbor, Alpha Centauri, and am steering a boat by the light of that celestial beacon, then the bodily organs involved in this mental act include eye and brain and muscle, all acting in reciprocal interplay Indeed, the dynamic system operating is more far-reaching than this, for the star is also an essential component It follows that the causal complex of which my conscious control of the course of the boat is one component embraces, not only an intricately linked series of very diversified bodily activities, but also events which took place 25 million million miles away and nearly five years ago, for Alpha Centauri is distant 4 35 light-years from the earth

If we attempt to view this causal situation in its entirety, we recognize a number of things and events which are localized in space and time and which are locally segregated as organs with specific functions, such as sense organs, groups of cooperating muscles, reflex arcs, and so on Each of these "partial patterns," as Coghill calls them, has a certain measure of unity and individuality These local and partial patterns are woven together into larger "total patterns" which involve integrated activity of the organism as a whole or major parts of it

Now, thinking is a total pattern It is not performed by any linkage of particular nerve cells or centers in fixed and stable combination, like the arrangement postulated in the traditional diagrams of the reflex arcs The search for localized cortical centers which perform the functions of perception, ideation, imagination or volition is vain These, it is true, are acts performed by the body and specifically by the cerebral cortex in a restricted sense; but no one of these acts is ever exactly repeated, the set-up of conditions is never twice the same, and the cortical apparatus at each successive moment of the ceaseless ebb and flow of nervous impulses through its inconceivably complex web of nervous pathways is under the influence of outside events on both the sensory and the motor side The sensory systems play upon the cortex at every moment of waking and sleeping life and all motor activities are reported back to the cortex and in turn influence subsequent cortical adjustments.

Our awareness of what is going on, the content of consciousness, is elaborated (we know not how) from these sensorimotor experiences These may be recombined in new patterns in imagination, fantasy and abstraction, but even invention and creative artistic inspiration can not go far beyond the domain of sensory experience The most inspired genius can conceive no glories that are other than kaleidoscopic recombinations of

what he already has sometime sensed. A scientific hypothesis is old facts reset and redirected, and the heaven of apocalyptic vision has gates of pearl, streets of gold and diadems of jewels of earthly form.

IV

Now we come back to the original question, What kinds of stuff are minds made out of? The answer seems to be that mindstuff is bodystuff. This does not mean that mind is matter or that matter is mind. Neither matter nor mind is inert structure. A structural psychology is to-day outmoded as completely as is the atomic physics of a generation ago Matter is not something passively acted upon; it is a very lively thing and its activity is inherent in its structure. The biologist is driven to the conclusion that some special patterns of material structure exhibit the properties (that is, the activities) of life. This living substance we call protoplasm Following the same line of evidence further, the conclusion is equally unavoidable that some special structural arrangements of protoplasm exhibit the properties of mind, that is, an awareness of some components of the flowing network of process which is characteristic of this particular kind of structure.

Life is still a mystery. We have not yet found a scientific formula for it Mind is still more mysterious. But the preceding statements seem to rest on the safe ground of well-validated scientific evidence The mystery of mind will probably remain, for if mind is a manifestation of the activity of structure, the mind can not know itself as awareness and at the same time have *direct* knowledge of the structural apparatus that performs the function of knowing

This seems to be an inherent limitation of our nature as finite beings. Our awareness is a process patterned in the four dimensions of space-time The apparently static structural patterns of naive experience seem like objectified cross-sections of the process, pictured as arrested motion like a single frame of a moving picture film. The temporal dimension is eliminated. But temporal relations are essential features of mentality. There are no mental states, only mental acts.

All our knowledge of structure is indirect, and must be so From this it does not follow that material structure is illusion or less real than mind The naturalist must be a practical realist—and so must everybody else, for if we do not adjust our conduct to the realities of the objective world we quickly perish.

Just as we have learned to use subjective experience as a token or representation of things and events of the outer world to which we must adjust and also of the operation of certain bodily mechanisms (as yet very imperfectly understood), so conversely we may use the behavior and bodily structure of other men and animal kind as objective tokens or indicators of what they are probably experiencing This indirect evidence about other minds than my own is more reliable the closer the resemblance between these other patterns of behavior and bodily organization and those which I myself exhibit. I feel, for instance, that I understand my wife's mind better than I do that of my dog and I am sure that my understanding of both of them leaves much to be desired

Since the organ and its function are inseparable, once we have discovered this relationship we can safely infer the presence of the organ if the function is manifested and the presence of the function wherever the organ is found. A competent zoologist can tell a great deal about the habits even of an extinct dinosaur from a study of its skeleton. We use in this way not only bodily structure, but evidences of animal handicraft, beehives, beaver dams, and the like. So also the archeologist may reconstruct and evaluate an extinct human culture, corre-

lating utensils, works of art and dwellings with skeletal remains, cranial capacity and cephalic index.

Because this indirect evidence is all that we have, we must make the most of it. This method is serviceable in proportion as our knowledge of both structure and function is complete and reliable. So we study comparative anatomy, comparative physiology and the comparative embryology of both structure and behavior. But the most comprehensive knowledge of these things will never take us to the desired goal unless all the facts are actually brought together and converged upon the particular individual whose vital processes are under investigation.

For an adequate understanding of the actual relationship between bodily structure and performance it is necessary to know the past life of the individual, both his personal development and his ancestral or evolutionary history. We look for sources, for beginnings, and then follow the steps of subsequent development and differentiation By way of illustration let us now summarize briefly two programs of research into the origin and early development of behavioral capacity of the individual.

We owe to the insight, skill and indefatigable industry of Coghill the demonstration of the importance and the practicability of this correlation of development of patterns of behavior with the organs which actually execute the behavior He selected for intensive study a primitive and generalized animal where the essentials of the problem are reduced to simplest terms, the salamander, Amblystoma This was a fortunate choice, for during the span of the forty years of his labor this animal has proved to be the most serviceable type for a wide range of researches upon fundamental biological problems

Dr. Coghill's first step was the determination upon statistically adequate numbers of specimens of the actual sequence of development of patterns of overt behavior which are characteristic of this species. He then took a series of specimens, each of which was known by test to have reached a specific stage in this physiological scale, and subjected every one of them to detailed microscopical study, thus revealing the corresponding series of structural changes. It has been my recent good fortune to repeat many of Coghill's observations on a different series of specimens prepared by methods different from his, with full confirmation of his findings These studies have stimulated many others, so that we now have comparable observations upon a wide range of animal species

It is already clear that the sequence of events in the process of maturation of the action system may be very different in the various kinds of animals. Amblystoma, which may hatch from the egg before the twentieth day and thereafter swims actively, shows from the start a different pattern from that of the toadfish, whose yolk-laden eggs develop more slowly It is unsafe to carry over generalizations from one species of animal to another without actual control by critical observation and experiment As the late W. K. Brooks used to say, "The only way to know is to find out"

Some men have been described as rats, but no rats are men The course of human prenatal development does not run exactly parallel with that of any of the other animals whose fetal behavior is now under investigation. Yet the difficulties in the way of successful prosecution of studies of human prenatal behavior are very numerous and baffling Fortunately several investigators have to varying degrees overcome these obstacles. The pioneer was Minkowski. The most completely documented and systematic observations are those of Hooker Parallel with the accumulation of these records of behavior, anatomical studies of the ac-

companying changes in structural development are in process. These researches yield a wealth of facts which can now replace speculation about many features of early human development which are of fundamental value in fields as diverse as embryology, physiology, anthropology, psychology and medical practice

These studies of embryological origins and subsequent differentiation do not go back to the beginning, for every individual is endowed by his ancestors with a characteristic hereditary organization This is his working capital as he begins his career as a separate person These inherited potentialities and limitations must be known and carefully invoiced and appraised Neither nature nor the natural man can make something out of nothing or perform any other miracle. It follows that the entire evolutionary history of the race must be surveyed to learn as much as possible about the genetic composition of the fertilized egg, for this tiny fleck of protoplasm has somehow concealed within it all the potencies which are transmitted to the germ from countless generations

My own attack upon the problem of the sources and growth of the apparatus of our mental capacities is directed toward a search for evolutionary origins Trained as a comparative anatomist and structurally minded, as an anatomist must be, I fortunately was taught when very young that structure has no meaning apart from what it does. There is general agreement that the human cerebral cortex is the master tissue in the control of our conduct It is equally clear that this cortex has been elaborated in the course of many million years of intense evolutionary struggle for survival from a simpler and more primitive sort of nervous tissue which is not cortex as we define it It may help us to understand the still unsolved mysteries of cortical activity to inquire where the cortex came from. Fishes have no cortex, though the rest of the brain is organized on much the same plan as our own. Can we trace the emergence of cortex from primordial tissue which is not cortex, and can we discover the agencies operative in effecting this transformation?

Our knowledge of the texture of the brains of fishes and of representatives of all groups of animals from fish to man is very extensive. We know the fossils of these various types of animals from early Silurian times until now, and from their skull casts we can restore the forms of their nervous systems and write a fairly accurate history of the evolution of the brain

From the assemblage of all available evidence it is obvious that when some primitive ganoid fishes developed lungs and were able to emerge from the water as air-breathers these revolutionary changes in the mode of life were reflected in the structure of the nervous system. This transition from primitive amphibian fishes to true amphibians was effected perhaps three hundred million years ago, and fortunately we still have with us living representatives of some of these transitional forms These are the critical species for investigation of early stages in the emergence of cerebral cortex from its primordial matrix in the cerebral hemispheres I have, accordingly, for now nearly fifty years devoted myself to the study of the minute structure of these amphibian brains, with especial attention to Amblystoma, the same salamander which Coghill employed in his classical researches

Even a brief summary of these investigations and similar studies by other comparative neurologists would require a thick volume of very technical neurological description It is possible to recognize in fishes and salamanders and frogs, which have no cortex, the parts of the forebrain within which cortex emerges in reptiles and to discern some of the physiological agencies there opera-

tive which prepare the field for cortical differentiation.

In the more primitive amphibian species most of the activities are generalized mass-movements Their brains, accordingly, possess few sharply localized reflex arcs, but the entire nervous fabric is woven together by an intricate feltwork of very fine and widely branched nerve fibers. This tissue we call neuropil. It seems to be the chief apparatus of integration of behavior and of those totalizing activities which the gestalt psychologists have brought to light and which can not be fitted into the stimulus-response formula It is also probable that it is employed in conditioning of reflexes—a learning process—and many other forms of modifiable behavior This neuropil, together with its derivatives in higher brains, such as the reticular formation, is the parent tissue from which all the more highly elaborated organs of integration and totalizing functions have been differentiated This non-specific and labile tissue and many complex cerebral organs derived from it may be regarded as an equilibrated dynamic system which operates more or less as a whole and in constantly fluctuating patterns depending on the sensori-motor activities at the moment in process in the more sharply localized tracts and centers of the analytic systems. The further differentiation of this tissue culminates in the emergence of cerebral cortex within particular fields of the cerebral hemispheres, and the early chapters of the history of this critical period in the evolution of brains can now be written.

We can also trace the progressive complication of the texture of the cortex in the series of animals from serpents to men and so arrive at some conclusions as to the difference between the wisdom of the serpent and the wisdom of man For, as Dr. Cannon has graphically shown, there is a wisdom of the body and, as I maintain, there is no other kind of wisdom.

V

The human brain is the most complicated structural apparatus known to science. If all the equipment of the telegraph, telephone and radio of the North American Continent could be squeezed into a half-gallon cup, it would be less intricate than the three pints of brains that fill your skull and mine More than half of this brain tissue is cerebral cortex and parts immediately dependent upon it The most ungifted normal man has twice as much of this master tissue as the most highly educated chimpanzee

This cortex is a sheet of grayish jelly spread over the convolutions of the cerebral hemispheres within which are embedded ten thousand million nerve cells It is a conservative estimate that each of these cells is in anatomical and (potential) physiological relation with at least a hundred other cells by means of an interwoven fabric of nerve fibers of inconceivable complexity The possibilities of functional patterns of interconnection among these nervous elements are practically infinite. These arrangements are not haphazard; they are orderly; and it is the neurologist's task to discover the laws of this order

Good progress in this program is already recorded, and the immediate future offers promise of still more rapid advance, for we have new points of view and new instruments of precision I have ventured the prediction that the recently developed electrical methods of recording nervous impulses by means of the oscillograph and radio tube amplifiers will enlarge the field of nervous physiology as fruitfully as the science of anatomy was revolutionized by the invention of the compound microscope.

Examination of the brains of animals from low to high in the scale and of mankind from early fetal stages to the adult reveals differences in texture which are directly correlated with patterns of behavior and presumptively with types of

experience. This presumption can be tested in the case of the human brain, where correlated studies in clinical neurology and neuro-pathology reveal numberless clear demonstrations of the relations between particular cerebral organs and various sorts of conscious experience

It is possible to trace, in the course of vertebrate evolution and in human embryological development the progressive maturation and complication of cerebral tissue, first in the older stem portion of the brain and later in the cortical fields, and to correlate these changes with the gradual transfer of control of behavior from brain-stem to cortex. The more stereotyped reflex and instinctive types of behavior have their central adjusters in the primitive brain-stem. The maturation and elaboration of the cortex comes later, and with it greater capacity for learning by personal experience and all the higher mental process which make this possible These two kinds of control of behavior—that is, the relatively stereotyped innate reflex and instinctive as contrasted with the more plastic individually learned—have a common origin in the adaptability of all living substance They are not sharply separated, and every human activity is a blend of both of them. Yet the distinction between them is of great practical significance, and increasingly so as we pass from lower to higher species of animals The nervous apparatus employed in the primitive subcortical types of adjustment is recognizably different from that of the cortical adjusters and the enlargement of our knowledge of these differences is now at the focus of interest, for this is the key-problem of physiological psychology.

VI

In my own experience the feature which seems most characteristic of the higher mental processes is the ability to use mental symbols of one sort or another as tools of thought. These symbols evidently have grown up by abstraction from many particulars of something which is common to all of them; thus all squares differ from all circles in easily definable ways, and for these differences the words are symbols Language is, of course, the chief vehicle of these symbols, but it is not the only one

The symbolisms of language, mathematics, pictorial art, and so forth are consciously employed Ability to use abstractions of this sort has grown up very gradually in the life of the individual and the history of the race. In its more primitive forms it may be, so far as we know, entirely unconscious All plants and all animals show some capacity to adjust their behavior to the uniformities of their natural surroundings In racial experience these common features have been abstracted from the heterogeneous environment and by natural selection or other biological agencies woven into the hereditary texture of their bodies so that they make these adaptive adjustments to the alternations of day and night, change of seasons, and so on quite "naturally" Here we see on the most elementary biological plane an abstraction from mixed experience of some general features which enable the animal to adjust himself in advance to future events before they happen, as when the fur thickens in preparation for winter and a bee, wasp or beaver lays by his store of food in a skilfully constructed dwelling

This "animal faith," as Santayana calls it, may be exercised blindly and unwittingly, but it seems to be the germ from which all higher types of abstraction and symbolism have grown. When a rat is taught to discriminate between a square and a triangle, regardless of size, illumination or arrangement of the test objects, we are dealing with a higher grade of abstraction which must be individually learned, for this ability is not

part of the rat's hereditary endowment. If this sort of learning has any intelligent control, it is of rather low order, though even in rats Dr. Norman R. F. Maier, of the University of Michigan, has objective experimental evidence of types of performance which fundamentally are indistinguishable from human rational behavior.

The progressive enlargement of this capacity for abstraction can be tested in terms of objective behavior. Experiments with monkeys by Kluever and Bucy are now in process which show that destruction of certain definite cortical structures may cause a mental disorder (agnosia, asymbolia) comparable with the simpler types of human aphasia The acquisition of symbols for abstractions provides a useful objective index of the growth of intelligence, whether the symbol is expressed as gesture or a spoken word.

Parallel with these studies of the development of patterns of behavior and comparative psychology, we have a series of anatomical descriptions which show a close correlation between the grade of performance which an animal (or a child) can exhibit and the structural differentiation of the nervous system. These details are intricate and technical, but I wish to make it clear that we are not merely guessing when we say that it is possible to cite a wealth of facts about the location, structure and physiological properties of the bodily organs employed in making mental symbols and in all those higher rational processes which employ them—in short, the semantic functions.

I have elsewhere suggested a biological classification of the kinds or grades of learning under three heads: First, organismic or protoplasmic learning, that modifiability by use or practice which is a general characteristic of all living substance, for all protoplasm can learn. Second, sensori-motor or neural learning, whose exercise requires a differentiated nervous system. This is typified by a rat's ability to learn to make an errorless run through a maze Third, semantic or cortical learning which works with ideas and mental symbols of various grades of abstraction. This kind of learning can not go far without the aid of language and is a token of our humanity It is distinctly a cortical function

The transfer in higher mammals of the dominant control of conduct and of the course of conscious experience from brain-stem to cortex and from physiological to psychological technique has momentous consequences The mental symbols elaborated in some unknown way by the integrative apparatus of the human cortex give to mankind new tools of adjustment which have extended the reach of his control from the present into the future The human brain, as Sherrington aptly expresses it, is "fraught with a germ of futurity."

Mental symbols and their objective signs in language, mathematics and so forth are the indispensable tools of the life of reason With the help of these tools mankind can preserve and profit by the past experience of the race as recorded in tradition and literature and by imagination and invention enlarge his understanding and control of the inorganic, organic and human agencies of production and enjoyment. And of far more importance, he can predict the future and lay out his present course of action in the light of probable future consequences of the present act The most intelligent brute lives mainly in the present Men attentively bind the past and the future into their present and thereby become as gods, knowing good and evil

This capacity for "time-binding," as Count Korzybski phrases it, is perhaps our most distinctive human characteristic. The ability to select from among several possible courses of action the one which intelligent foresight indicates will

at some future time yield the satisfaction desired provides the key which opens doors of opportunity which are closed to all the brute creation We are free to make choices in the light of past experience and to make up our minds about what we propose to do about it in rational judgment. This free voluntary choice sets the musty problem of the freedom of the will in a natural frame unobscured by any fog of mysticism, because this life of reason is part of our natural lives as sentient beings.

It is this which makes it possible for every individual to lay out an intelligently planned program of self-culture which shapes the course of his own growth in competence and the achievement of higher satisfactions. It is part of our apparatus of regulatory control, and it carries with it a personal responsibility for character building and for all the conduct manifested by the characters which we have built. Our natural freedom involves an equally natural responsibility. And this becomes, by definition, a moral responsibility as soon as a social component enters into the intelligent analysis of situations requiring the exercise of voluntary choice.

This is what our brains are good for, and the salvage of our civilization from its present peril of reversal to barbarism depends on our capacity by educational and other means to cultivate in all our people a more intelligent appraisal of the values sought and ability to curb irrational passion and selfish greed for wealth or power in the interest of those social values which make civilization possible. At the present stage of human culture a stable social organization is absolutely essential to personal welfare This implies a proper balance between personal profit and the public good, and this is what we mean by moral conduct We have, in fact, reached a stage of cultural evolution where some of the moral values have actual survival value Without them our civilization perishes and we perish with it

It follows that a natural system of practical morals can be elaborated from this simple principle · That social stability upon which the survival and comfort of the individual depend and that moral satisfaction upon which his equanimity, poise and stability of character depend arise from the maintenance of right relations with our fellow men The right relations are those which are mutually advantageous.

CUTTHROAT COMPETITION IN THE SEA[1]

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LEST the terminology lack significance to others, let me explain the wording of my title. Perhaps it has been two, three or more decades since I first heard the phrase "cutthroat competition" applied to the life and death struggle between and among many kinds of business enterprises. Whatever, however and whenever the occasion of its use that first attracted my attention, it made a strong impression upon me Since then it has always carried the idea of desperate, heartless and insatiable strife for place and the means to sustain it As my acquaintance with life and nature "in the raw" has expanded and progressed this idea has been transferred with slight modification to the relationships of lower organisms Although we may not be able to say properly that they are vicious and heartless in their struggles for place and maintenance, it is surely correct to say that they, no less than man, are desperate and insatiable in their competitions with each other

Ordinarily, so far as our acquaintance with human competition goes, we are disposed to think that Tom Jones, the plumber, has no competition with Bob Tate, the grocer, and that Richard Roe, the doctor, has no competion with John Doe, the lawyer. We are more familiar with conditions under which grocers are against grocers, doctors against doctors, lawyers against lawyers, and plumbers against plumbers. This is especially true when the means of maintenance are limited in any of these fields or others like them. But, as a matter of fact, any or all of those just mentioned may come into competition in seeking homes or favorable sites for business So it is in the sea. When certain conditions exist an organism may find competition only with those of its own kind seeking place and sustenance. But, certain other conditions may remove competition between kin while introducing competitions with widely different creatures

Numerous aspects of competition of marine organisms might be mentioned, a few of which are selected for present discussion. To me, cutthroat competition appears to be more evident and more impressive among sedentary animals and plants, those living attached to solid objects as distinguished from those afloat (plankton) or those swimming (nekton) in or through the water. But discussion of their vicissitudes of existence may be clearer after references to the flotant (planktonic) and natant (nektonic) forms

In Southern California seas many different kinds of animals, including man, prey upon the sardines Under the stress of competition when sardines are relatively few it is probable that other animals would take the same attitude as man if they were able to establish or exhibit attitudes They might accuse him and each other of reducing the supply, just as he accuses sea lions, sharks and birds If given opportunity, all would attempt to get rid of competition by destroying the accused competitor Lacking the ability to establish that attitude, the enemies of the sardine frequently make up for it by engaging in a race to kill which has some of the typical features of cutthroat competition, especially viciousness and heedlessness. When one sees a school of sardines being decimated or destroyed by ravenous barracuda, mackerel, bonita and

[1] Contributions from the Scripps Institution of Oceanography. New Series No 58.

sharks, in the water, aided by swooping pelicans, terns and cormorants from the air above, he wonders that any small fish should be able to survive

But, although less abundant than formerly, sardines do survive On most days when the sea is smooth in clear weather half a dozen or more small schools may be seen from the laboratory windows of the Scripps Institution of Oceanography as they ripple the surface of La Jolla Bay. In one way it seems probable that competition of their enemies in destroying them has favored prosperity of sardine survivals by diminishing their own competition for food One does not think of the sardine as a ferocious animal, yet it seems to be reasonably clear that if sardine numbers increased excessively their food supply would be consumed and diminished to the point where desperation of competition for sustenance among them would be as severe as that among the enemies engaged in their destruction

The food of sardines consists of a number of different kinds of plankton animals and plants, all small and many microscopic. In Southern California seas the tiny crustaceans called copepods contribute largely to the food supply of these fishes Some copepods are predatory, but most of those under notice here are plant feeders, living on diatoms, dinoflagellates and other microscopic plants. Inasmuch as they pick up this food material while swimming feebly through the water, there is not much opportunity for individual conflict over particular items Like larger herbivorous animals, they browse along without much attention to each other Even when food is scarce, it is difficult to see how they can oppose each other forcefully while getting it. Rather, we must suppose that the stress of competition between individuals appears only in seeking and grasping food particles over a wider range than usual, thus menacing the supply for others without direct conflict. But, of course, this kind of competition may be as desperate and interminable as any.

Nor do the microscopic plants which constitute the phytoplankton escape competition. Through most of the year, in most seas, they are likely to be few in numbers and irregular in locality occurrence or distribution. One drop of water may contain a few to several individuals, while neighboring drops in that locality have none. In another locality few drops of water contain any Investigators suggest that in one case light is not favorable, in another case that phosphates are deficient in quantity, in another case that temperature is not favorable, in another case that overgrazing by animals has made or kept the plant populations small, and so on Whatever the unfavorable influence or lack of influence or the unfavorable combination of influences may be the condition almost always marks a period in which competition is negligible, the organisms present being spaced too far apart from each other to make any essential difference in the use of materials obtainable

But, now and then, there are periods of days or weeks in which a combination of influences favors rapid growth, development and multiplication of microscopic plants of many kinds or of some particular kind Toward the end of such periods the abundance of one or more kinds may increase until the sea water is discolored and looks "soupy."[2, 3, 4, 5] At such times one or more hundreds of individual specimens may be present in each drop of sea water over an area of several or many square miles through depths from the surface to one hundred feet or more While there is still a great lack of information concerning the func-

[2] W. E Allen, *Quart. Rev. Biol*, 9 161–180, 1934.

[3] H B Bigelow, *Bull. U. S. Bur. Fisheries*, 40. part 2, 1926.

[4] E. Haeckel, "Planktonstudien." Jena, 1890.

[5] H N. Moseley, "Notes by a Naturalist on the *Challenger*," London, 1879.

tional activities and physiological conditions of such dense populations it is well known that supplies of phosphates, nitrates and other nutrient materials are diminished in the area occupied. Therefore, it is reasonable to suppose that life and death competition for sustentative materials exists, even though it lacks any suggestion of strife of one individual against another

So far I have noticed only those organisms which generation after generation spend their lives suspended (floating or swimming) in sea water. In addition to such as these there are vast multitudes of different kinds of animals and plants which spend only parts of their lives or cycles of existence in the same way. Populations as dense as any mentioned above are very common for short periods in certain tide pools, where sex cells, larvae and other floating or swimming forms are released in clouds by fixed (sedentary) organisms at favorable times The water over almost any beach is likely to be clouded temporarily with reproductive materials and products or with propagating units at appropriate seasons of the year. Inshore waters in general may contain large numbers of plant and animal units of one kind or another at any time of year in warmer seas, some detached by surf or wave action, others normally detached forms of propagative or reproductive character Sometimes these transitory populations take residence in coastal water masses at a time when they are occupied already by vast numbers of permanent residents. In such cases, competition of all kinds may reach critical intensity in the locality, some organisms competing for such operating essentials as oxygen to breathe, others competing for foodstuffs, still others competing for light, and all competing for space to be occupied by their bodies In such populations one kind of competition will be found much more prominent than it ever becomes in populations of offshore waters; it is competition for reproduction Throughout most of the year any kind of a population in offshore waters is mainly active in growth and development. Even when a reproductive period involves a dense population, *e g.*, one of sardines or copepods, it is not probable that reproductive competition is very great, the eggs and sperm being scattered in the water so rapidly that relatively few sex cells meet excessive numbers of the opposite type Inshore, the condition is likely to be different, each egg liberated in a tide pool being surrounded by enormous numbers of sperms competing for union, or each female organism being besieged by great numbers of struggling males

Among the larval or juvenile forms of sedentary organisms found in coastal waters another kind of competition of utmost urgency appears as individuals get ready to attach themselves for the stationary phase of existence In most localities unoccupied surfaces with satisfying characteristics for young home-seekers are relatively rare. Not only are appropriate submerged surfaces or surfaces frequently submerged already occupied by animals and plants of a preceding generation, but many surfaces which lack full fitness for occupancy are also in use Therefore, in trying to find a lodging place the new settler is confronted with opposition (passive or active) from old settlers of many kinds in addition to rivalry of those of its own generation

Under these circumstances the outlook for youngsters of most kinds seems very dark, even hopeless. And, one might suppose that the competition for space would be extremely one-sided, nearly all the fatalities being among those who seek rather than among those who possess. However, no data have ever been compiled which are adequate to support an absolute generalization to this effect. No matter, the finding of acceptable lodgment by a successful seeker does not solve or terminate the problem of space rela-

tionships. Except, perhaps, for certain unicellular forms the act of process of attachment and settlement is merely the beginning of a period of growth and expansion in which the need for more and more space is just as urgent as ever until the end of that phase of existence is reached. Many different kinds of sedentary animals and plants live under perpetual continuance of this stress of strife for place, barnacles, oysters, mussels, bryozoa, tunicates, hydroids, serpulids and a number of different kinds of "sea weeds" being especially prominent in numerous localities in Southern California waters.

Of these, the "California striped barnacle" (*Balanus tintinnabulum Californicus*) is especially favorable for attention, partly because of its great abundance and partly because of its rigidity of shell structure and the protuberant habit of growth. Years ago, Visscher[6] found that barnacle larvae ready for attachment under experimental conditions were inclined to be meticulous, trying out one and another and still other spots on the surfaces offered for their attachment. It is difficult to believe that they would always behave this way in their natural habitat with myriads of their kind trying to find points for fixation at one time. Surely the need for haste would be so great that fastidious testing would be impossible, at least at the period of greatest abundance when the number attaching may be as high as three hundred per square inch.[7] Certainly, several of the points selected by individuals in Fig. 1 seem to have been chosen without much attention to fitness, either because of the race for position or because of the diminishing range of choices as all spaces were filled. However, the fact that some of the surfaces of shells of the larger individuals lack occupants may mean they had been tested and rejected for cause, although they may look to us much more favorable than the case of shell upon shell upon a shell attached to a fourth shown in Fig 2. Still, there is plenty of evidence that preferences exist, not only for certain materials but for certain positions on solid objects.[8, 9, 10]

The small insulated wire upon which this dense colony (Fig. 1) of small barnacles found lodgings was used to hold in place some submerged experimental plates at the pier of the Scripps Institution of Oceanography. It received no definite attention until after the colony had become conspicuous. Therefore, the history of the attachment activities is unknown. However, there was evidence to indicate that the surfaces of insulated parts were occupied much more quickly than the bare copper (if the latter was occupied at all, a matter difficult to determine positively because of the smallness of the bare area and because of overlapping or bridging of shells from insulation material). At any rate, crowding was more conspicuous and growth was far greater on the insulation material than on or over the copper Evidently, the homeseeking larvae found the insulation surface so attractive that they tried to reach it again and again.

Directly or indirectly (shells on shells) more than one hundred larvae found attachment on the four-inch section of this wire (Fig 1) It is impossible to guess the total number because many which had found lodgment at one time must have been destroyed without trace, leaving evidences only of the number mentioned. Of these, about twenty reached a shell diameter near one third of an inch, most of them being attached directly to the wire It may be supposed that these had found lodgings on the wire soon after submergence, four weeks before its removal.

[6] J Paul Visscher, *Bull U. S. Bur. Fisheries*, 43: Part 2, 1928.

[7] W. R Coe, *Bull. Scripps Inst Oceanog*, Tech. Ser., 3: 37–86, 1932.

[8] J. Paul Visscher, *loc. cit.*

[9] W. R. Coe, *loc cit*

[10] W. R Coe and W. E Allen, *Bull Scripps Inst. Oceanog.*, Tech. Ser, 4· 101–136, 1937.

But, a few were attached to shells of first settlers, which they resembled in size, doubtless because their superior positions not only enabled them to feed and breathe better but also because they reduced the supplies for the older animal. However, the first comer may have destroyed several of his fellows by expansion of his shell from pin-point size to bean size. Certainly, if several of the larvae of the first brood settled within one ninth of a square inch of the newly submerged surface all but himself were destroyed by the survivor, who may have been favored by first attachment and oldest growth, by ability to build shell most rapidly, by ability to build most resistant shell, by superior success in getting food or by other conditions and circumstances Whatever the points in its favor may have been, the fortunate one was able to destroy rival residents on the space occupied by it at the time of observation Coe[11] says that "only three or four barnacles can reach sexual maturity on any square inch of surface" and "with 200 to 300 young per square inch, even if regularly spaced, the mortality due to overcrowding must approximate 98 to 99 per cent" Competition for fixation space, therefore, appears to justify fully the application of the term "cutthroat competition."

But, competition between barnacle kin is not restricted to strife for place and space Setting of one barnacle shell upon another has been mentioned in the preceding paragraph along with a suggestion as to interference with feeding and breathing. This suggestion deserves a little more attention Suffocation and starvation may be caused in at least two or three different ways. Doubtless this fate is forced upon neighbors most frequently in newly formed colonies by individuals so fortunate as to get a lead in growth and development. Standing a little farther out from the surface than others, they get a choice of every kind of needed substance available in the water, and this in turn enables them to grow out farther. Some even overlap less fortunate individuals or join a large neighbor in bridging them over. Perhaps less frequent is the condition in which one or more newcomers attach themselves near to the peak of the resident shell of a large specimen or even on its outer margin, sharing in the materials collected by the occupant's activities until themselves large enough and strong enough to take nearly all as they extend their own shells across the mouth of the old one

FIG 1 CROWDED BARNACLES
ON FOUR INCHES OF INSULATED WIRE, EIGHTH INCH DIAMETER. SOME GAPS DUE TO SHELLS BEING DISLODGED SINCE DRYING BEGAN

It should not be supposed that competition among barnacle kin is always, or often, so evident or so prominent as might appear from foregoing illustrations It just happened that this wire was exposed at a time especially favorable for showing barnacle activities without much

[11] *Loc cit*

FIG 2. SUPPORTING SHELLS
NEXT TO LAST SHELL TO RIGHT ON WIRE SUPPORTS SERIES OF FOUR SIZES, THE SMALLEST SHELL LOOKING LIKE A PIN-HEAD EXCRESCENCE AT EXTREME LEFT AT TOP

evidence of other kinds of growth. Under ordinary natural conditions it is probable that rivalry of barnacle against barnacle might escape notice because of the prominence of competition of other kinds of organisms Even in the wire dwelling colony there was a considerable beginning of encroachment of other living things, the most prominent being worms of two kinds, one a serpulid building white, calcareous tubes on surfaces of the barnacle shells, the other a dweller in sand-walled tubes fitted into angles and crevices around the bases of barnacle shells The latter kind usually offers little threat to barnacle prosperity, but the former always carries the possibility of serious interference with welfare of individual barnacles or even small colonies For one thing, these worms use some of the same kinds of materials needed by barnacles, but principally they endanger the latter by their capacity for multiplying so rapidly at times that they may cover barnacle shell openings more or less and cause suffocation or starvation of the occupants

In nine years of continuous observation of sedentary ("fouling") organisms in La Jolla Bay, Coe and Allen[12] found serpulids conspicuous in only one Ordinarily they might show large abundance at times, but not in a way to suggest intense competition among themselves or very great interference with lives of other creatures In August, 1935, *Eupomatus gracilis* appeared in such abundance on experimental equipment at the pier that they not only crowded out many other things but overlapped their tubes to such depths that many individuals in lower strata must have been killed At about the same time they appeared in enormous numbers in San Diego Bay, choking with their tubes the condensers on certain vessels of the U S Navy (Coe and Allen[13]) This record of high abundance of *Eupomatus* is interesting and important because it illustrates the fact that populations not usually significant (at least in appearance) may become so at some time or other, either because of biological periodicity or because of fortuitous combinations of conditions favorable to their multiplication and development From consideration of phenomena of this kind it seems necessary to conclude that any living thing may become highly competitive against its own kind, or other kinds, whenever the right combinations occur, no matter how peaceable, insignificant and innocuous it may appear to be in ordinary routines of existence

One of the small crustaceans observed in La Jolla and San Diego Bays offers a still more striking example of this phenomenon, inasmuch as it had been not even noticed on the experimental equipment until 1933, although recorded from

[12] *Loc cit*
[13] *Loc cit*

detailed examinations. This little animal was the amphipod, *Erichthonius braziliensis,* which occurred then in dense colonies living in mud tubes several layers deep. As observed before that time, the few specimens living in single tubes or scattered groups of a few tubes twined about the bases of algal, hydroidal and other small growths seemed entirely negligible in relation to the general welfare of the fixed populations In 1933 they were noticed first in a colony having the form of a small island of mud in the middle of the surface of a glass plate 8 × 9 inches square This mass stood out about a half inch from the plate, and it was riddled with the openings of the tubes, the walls not being readily distinguishable Except for their short legs and lack of wings these animals were about as large as a mosquito They were very lively, and they could move back and forth through the tubes with considerable speed Therefore, it is not likely that those inhabiting the deeper tubes were seriously hampered by those in the outer ones This seems the more probable because enormous colonies observed in San Diego Bay on the flat bottom of a barge inhabited a mass of mud more than twice as thick, and those in lower layers seemed to be just as vigorous as those in outer layers. 1933 was their "big year" in La Jolla Bay (Coe and Allen[14]) their volume on an experimental plate reaching the surprising peak of 85 per cent of all organisms on it in July. In 1934 they were fewer, but large numbers were observed again in September and October, 1935, at the end of the series of researches Their near monopoly of the experimental surface in 1933 suggests the possibility that they could suppress competition from other sedentary animals without developing fatal rivalry among themselves However, it is difficult to believe that even if they reached this condition they could maintain it for long, the density of their population being entirely too great for proper sustenance over any considerable period of time in restricted space It is to be expected that, as in cases of land animals familiar to most of us, a period of high prosperity due to abnormally good supply must result in wholesale destruction due to intensity of competition when supplies decrease to normal or less than normal

In some respects Bryozoa are the most

[14] *Loc cit*

FIG 3 THICK, BROAD GIRDLES OF MUSSEL COLONIES
SHOWN ON PIER COLUMNS BETWEEN TIDAL LIMITS

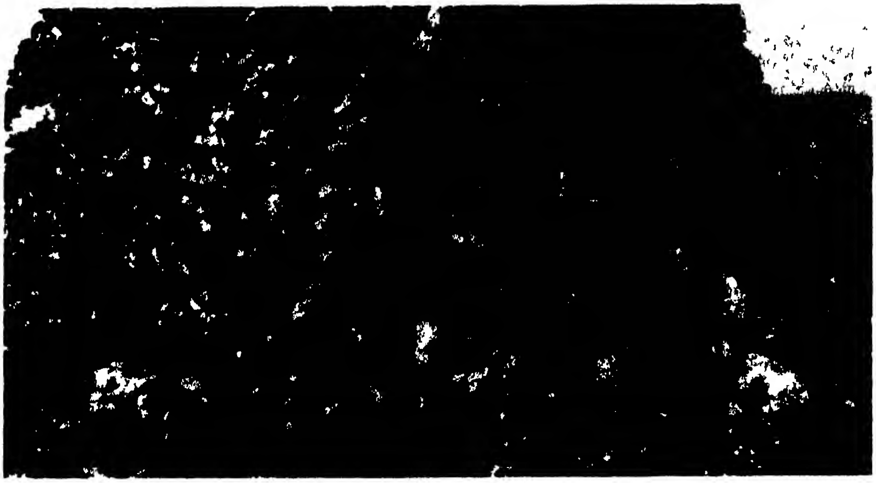


FIG 4. DETAILS OF EXTREME DENSITY
SHOWN IN COMPETITION FOR PLACE AND SPACE OF MUSSEL AND ASSOCIATED POPULATIONS IN A PIER COLUMN GIRDLE

interesting of the many kinds of competitors for space and place on experimental equipment The two species of *Membranipora*, in particular, are most astonishing because of their ability to win against almost any of the larger, as well as against the smaller, sedentary animals of the inter-tidal zone Many cases have been noticed in which a colony has spread its thin calcareous crust over single barnacles or groups of barnacles, forming a mantle through which the victims could not thrust their appendages or reach air and sustenance. Perhaps no phenomenon observed among marine animals gives so strong an impression of inexorableness as does the sight of one of these deadly encrustations spreading over prosperous masses of larger animals already resident When conditions are right for these bryozoans there are few of the shell-building animals which can meet their competition for place

To any one who has seen the cement columns supporting the pier at the Scripps Institution of Oceanography lack of mention of the salt-water mussels would appear to leave this discussion incomplete At low tide even a stupid and untrained observer would be impressed by the enormous girdle of mussel colonies around each column between tidal limits (Fig 3) On those about a thousand feet from shore all these girdles extend out nearly a foot from the cement surface at the densest part They are composed mainly of mussels of all sizes from a fraction of an inch to several inches in length, but they also include an amazingly large number of barnacles, oysters, bryozoa, worms, hydroids, algae and other things (Fig 4) If one had the ability to analyze the differing activities and the genius to trace the interrelationships of the whole assemblage of creatures he would probably find every aspect and every degree of competition between kin and non-kin Lacking these qualifications, he can still find interesting features easily and quickly Most prominent is the evidence of competition of mussel against mussel

No more than among barnacles do mussels respect the rights and interests of their neighbors (Fig 4) The fact that in most clusters the shells tend to point the same way might suggest that they fix themselves side by side in order to insure

least possible interference of one with another More probably, this tendency toward uniformity of position is due to orientation to obtain the best available supply of water-borne necessities Certainly there are plenty of individuals which attach themselves on or about the shell of a neighbor in a position which cuts off most of a regular flow of water Only the turmoil of waves and breakers prevents the condition from becoming disastrous So far as the pier is concerned, mussel growth is heaviest on most columns in a section midway between ordinary high-water and low-water marks The most favorable zone seems to be about two or three feet in depth, not a very promising outlook for larvae liberated by millions to seek lodgings in competition with each other as well as with those already in possession Nor does the stress of competition seem to be appreciably relieved by success in attachment As soon as it takes up residence the young mussel finds itself in the midst of a life-and-death struggle to obtain room to grow and to obtain food and air to sustain the growing

It is well known to biologists that cutthroat competition among kin in nature is not so completely evil as it seems at first thought The one and only fundamental objective of any and all species is self-perpetuation Nature rarely tolerates and never encourages development of equilibrium in any kind of population relationships Usually, there is distinct ebb and flow in prosperity and adversity To this condition each successful species must adjust and adapt itself For example, when food is abundant and enemies few it accelerates its growth of population, largely by bringing to maturity great numbers of individuals of inferior strength, hardihood and adaptability But the species, itself, has no automatic regulator to stop this expansion as a danger point is approached When the rate of population expansion exceeds the *rate of supply* of food, or when the rate of diminution of food supply exceeds the rate of adaptability of the population, selective starvation (weakest getting least) operates to take out those weakest or least hardy or least adaptable Thus the superior part of the population is enabled to survive, cutthroat competition favoring the strong and able as against the weak and incompetent If the onset of extreme adversity resulted only in all individuals sharing alike, the population would deteriorate, would be unready to take quick advantage of the next period of favoring conditions, and the future of the species would be jeopardized

If it were not for predatory and parasitic enemies cutthroat competition among kin would be more frequent and deadly than it is Many populations in nature are reduced to small numbers of hardy, resistant and capable individuals by epidemic diseases, sometimes before intraspecific competition has reached the cutthroat stage The mussel colonies on the pier at the Scripps Institution show an interesting example of the influence of a predatory animal on development of intra-species competition Large starfishes are always present on the colonies of the seaward supporting columns, and nearly always it is possible to see within a foot or two on all sides of one a striking array of empty shells of mussels which have been devoured Perhaps no other kind of example could be found which would show more convincingly the influence of a predator in removing representatives of a species from deadly competition with their fellows

Horrifying as it may appear to some of us, cutthroat competition is yet one of the most important and common of natural phenomena There exists no way to estimate the value of its influence, but it must be profound Apparently, some populations are regulated by it almost entirely, although one might have difficulty in proving it for any particular species

A FIRE IN A FOREST NEAR CORAM, MONTANA

FOREST CONSERVATION AND NATIONAL SECURITY

By RICHARD F. HAMMATT

ASSISTANT TO THE CHIEF, UNITED STATES FOREST SERVICE

CONSERVATION has had many meanings. Theodore Roosevelt gave it body and substance through National Forests, Taft through oil, Wilson through National Parks Not so long ago it was called " a boon to politicians," "something the public has always approved of" and "the chosen synonym of everything the New Deal is doing "

These are overstatements, but there have been bases for them Early public-domain and natural-resource scandals involved people of high and low degree Conservation was one of Theodore Roosevelt's "big sticks " Franklin Roosevelt plays its diapason through a program that includes the Agricultural Adjustment Administration, Soil Conservation Service, Domestic Allotment Act, Taylor Grazing Act, Tennessee Valley Authority, Civilian Conservation Corps, Youth Movement, Farm Security Administration and the Social Security Act

In one way or another all these have to do with conservation So the term is now pretty broad Yet the first resource it was applied to was the forest, and it is in connection with forests that most people think of it To some of them conservation still means preservation "Cut not a single tree" is their idea, and they advocate using substitutes in place of wood Others look at forest conservation as a huge job of reforestation, of planting billions of trees on millions of devastated acres By larger numbers it is thought of as the physical task of assuring an adequate supply of forest products

But there is now a deepening concern in its social implications and responsibilities This is as it should be, for as a public policy forest conservation's major purpose is to add to human welfare And this purpose applies to all resources of forest lands and all the many services and functions they perform

Water from forested slopes is one of those resources In the West it is the life blood of irrigated crops that enter world-wide as well as national and local markets Power from water is the backbone of industries that employ hundreds of thousands of people More than 400 cities and towns depend on domestic water from National Forests alone Just before the 1936 flood on one of the tributaries of the Susquehanna River, nine tenths of the rain falling on a potato field was lost as run-off This water carried with it more than 1,000 pounds of soil from every plowed acre But a neighboring forested area lost only one half of one per cent of the precipitation, and no soil Forest cover can not prevent all floods or hold all silt at its source, but this illustration—chosen at random from records of the 12 Forest Experiment Stations through which research activities of the Forest Service are directed—indicates how forest soils help lessen damage by floods and erosion

Forage is also a forest-land resource In certain Montana counties with which the writer is familiar a 55-million dollar investment and the livelihood of more than 5,000 people depend largely on use by domestic stock of grass, weeds and browse in local National Forests. Big game populations, receding alarmingly with human settlement, reached an all-time low about the beginning of the

A BARREN 200 SQUARE MILES IN CHIHLI PROVINCE, CHINA

A CENTURY AGO THESE HILLS WERE HEAVILY WOODED, YIELDING RICH REVENUES FROM FOREST PRODUCTS

present century But in the National Forests as a whole they have increased 150 per cent since 1924 More than 1,750,000 big game animals now depend in summer on forage these public properties provide

Wildlife is therefore a resource in its own right So is recreation, for forest lands offer priceless spiritual and cultural values to people who, under stresses of modern life, need escape now and then to a more primitive world geared to a slower speed And forests themselves provide building materials and fuel Wood yields such things as alcohols and rayons, naval stores and newsprint, perfumes and plastics Farm woodlands provide forest products each year that are valued at more than 100 millions of dollars Thirteen million people are supported by workers employed in primary forest industries, in growing forests, in selling and transporting forest products and as wood-working artisans

With such values and services at stake it seems pertinent to review what has happened to our forest lands and what is happening to them now, and to indicate what part many foresters think forest lands and their resources may play in bringing added security to the nation, and how they may do it

America has had a wonderful youth Her growth has been remarkable Her own population, and foreign demand for her goods and products, have challenged production by labor, by industry and by agriculture Boldly meeting that challenge, a self-reliant people has established new industries and conquered new frontiers, settled new lands, tapped new supplies of natural resources, and—drained them The forest was one of those resources

Ever since Colonial days, when they covered 820 million acres in what, exclusive of Alaska, is now the continental United States, forests have provided food

and clothing and shelter Larders of Pilgrim Fathers were stocked with venison and wild turkeys Coonskin caps and fringed buckskin protected scouts and trappers. Trees helped make log cabins and cradles, towns, telephone lines and transcontinental railroads Forests were vital to the winning of the West and the building of a new nation Few people thought, in early days, of conserving a resource that then seemed limitless

Conditions now have changed As a country we are emerging from our youth Two hundred years ago people produced slowly, on a small scale, with simple tools operated by hand Now science gives us complicated machines, and they tend to displace human labor Two men and a mechanical ditch-digger accomplish what 44 men with shovels once did To make—and fold—a four-page newspaper used to call for 250 hours of human labor Thirty years later it required only one hour, thirty-nine minutes and thirty-six seconds A single mechanical cotton picker can now do the work of 60 to 80 field hands

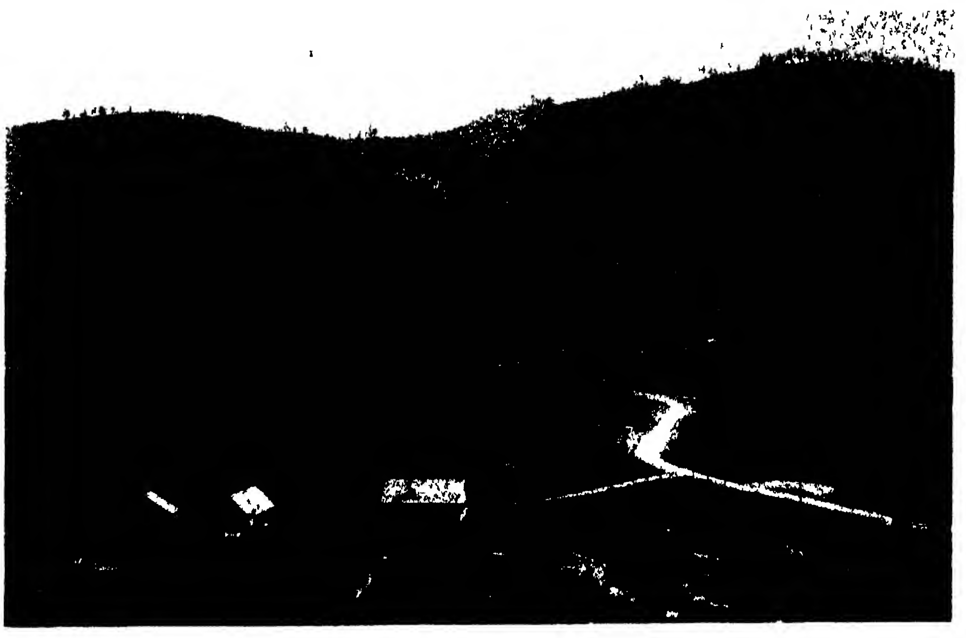
By generally accepted standards these things represent progress Yet estimates indicate that forest drain exceeded forest growth by about 2 to 1 in all sizes, and by about 5 to 1 in saw timber sizes, during the period 1925 to 1929, inclusive And although we still have 630 million acres of forest land, only 462 million acres are capable of growing commercial forests of this only 215 million acres now bear trees large enough for saw timber

These latter figures are based on a nation-wide forest inventory Undertaken by the Federal Forest Service, its purpose is to find out what forests we have and where they are, how much forest depletion there is, and how and where it takes place, what we need in the way of forest products, how much forest growth we have, and how much we can expect under real protection and management This inventory, though not yet complete, is far enough along to indicate that

(1) Although generations hence a few hundreds of thousands of our 630 million acres of forest land may be needed for

THE FALL ROUND UP IN BEAR VALLEY

PAYETTE NATIONAL FOREST, IDAHO NATIONAL FORESTS ARE ADMINISTERED ON A MULTIPLE USE BASIS



THE WORK OF MAN AND FIRE
THIS AREA NEAR THE KANIKSU NATIONAL FOREST, IDAHO, ONCE GREW FINE FORESTS AFTER BEING EXPLOITED, IT WAS GUTTED BY FIRE IN 1932

some other purpose, with minor exceptions most of it is and probably always will be most valuable in forest growth

(2) From the standpoint of producing lumber, ties, poles, firewood—and newsprint, plastics, distillates, rayons and thousands of other things derived from wood—168 millions of these acres are "out" Kept in forest growth they help save many farms and cities from erosion and floods, safeguard and help regulate water, provide food and shelter for big game, and opportunities for millions of people to enjoy simple recreation But because of factors like poor soil and inaccessibility these 168 millions of acres do not now and probably never will produce commercially worth-while forest products.

(3) Of the 462 million acres on which we should be able to count for forest products for human use, 73 million acres have already been so badly cut and slashed and burned that they are now virtually non-productive Another 174 million acres now bear trees too small for saw timber, and in general are not heavily enough stocked to produce what they can and should The balance, 215 million acres, does have trees of saw timber sizes This area includes our remaining virgin forests But annual drain of saw timber species and sizes commonly used continues greater than the annual growth of those sizes and species

This doesn't seem particularly reassuring There are conditions that make it less so. The best three fourths of all commercial forest land is in private ownership, and most operations on these lands are still geared to practices that threaten the existence—or the stability—of community after community

This is not true of all these operations. In northern Mississippi and southern

Arkansas, for example, the writer has seen some of which any one might well be proud Instead of being mined, these forests are cropped and renewed, and in this process forest growth is increased But although credit is due these leaders they are—with or without their knowledge and consent—being used as a smoke screen by that big majority of operators and owners that still clings to quick liquidation to that old cut-out-and-get-out practice that has been responsible for ghost towns—and human misery—from the Catskills to the Cascades and from Canada to Mexico

This is the practice that in large measure has also been responsible for shortages of valuable species and grades once produced in abundance in many localities and regions Many of these regions and localities still have forests of a kind, and still produce forest products But output is in large part confined to less desirable species and grades, and is often insufficient to meet local needs. Under these conditions many regions and localities now use less than they really need, import little because (with hauls so long that transportation sometimes doubles the price) many forest products are luxuries to people who have most of the buying power

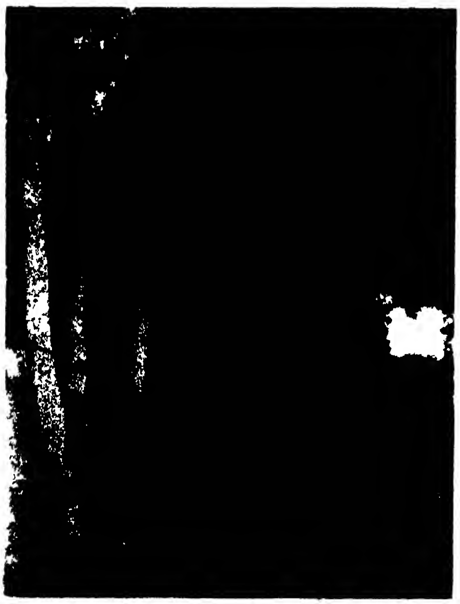
The forest inventory indicates, however, certain mitigating conditions The 73 million acres previously mentioned are still *capable* of producing commercially valuable forests Annual growth can be speeded up on the 174 million acres that now bear trees too small for saw timber And both this area and the 215 million acres that still have saw-timber trees are *capable* of producing much more than they now do

These and related facts seem to warrant the belief that unless abuse and neglect continue we probably have enough

VIRGIN TIMBER IN THE COEUR D'ALENE NATIONAL FOREST, IDAHO

A FIRE OBSERVATION TOWER

LOOKOUT (WITH GLASSES) AND SMOKE-CHASER (READY TO GO) LOCATE FIRE FROM JACK KNIFE RIDGE, COEUR D'ALENE NATIONAL FOREST, IDAHO



WHITE BIRCHES IN NORTHERN MINNESOTA

forest land, that with care and forethought—with a forest policy and action programs geared to current conditions and future needs—there need be no excuse for a timber shortage of national proportions. They also indicate a way out for hundreds of thousands of families suffering now for lack of work. For forest restoration and improvement of forest stands could provide work for these people. And the one could make idle lands productive again, the other could increase growth, and the proportion of the more valuable species in the stand. The two, through forest work, could create new wealth.

The extent to which this might be done is hinted at by certain investigations conducted in loblolly pine (*Pinus taeda*) in Arkansas. Briefly, Mr. Henry Bull, silviculturist at the Southern Forest Experiment Station, has determined that with the current average degree of understocking, an acre of loblolly pine in Arkansas will produce 4.5 times as much cellulose per acre as the average acre of cotton does, that if fully stocked and fully producing, the average acre of loblolly pine in Arkansas will produce 11 times as much cellulose per acre as is produced on the average acre of cotton.

The part forests have played in our national income and the part they can be expected to play in future income also indicates the extent to which more and better forests might create new wealth.

Figured as the money equivalent of goods produced and services rendered, the total national income was approximately 80 billions of dollars in 1929. Disregarding certain intangible benefits from forests, but including cash values for wood products, for water conservation and for wildlife and livestock production, about 3 billions of our 1929 national income can be credited to forest lands.

Contributions forest lands can make after rehabilitation and development

have become effective must be evaluated on the basis of certain assumptions that as time goes on will be subject to many influences and interpretations Such an evaluation, though it can not be made too closely, points to significant probabilities One is that the national income from forest lands and forest products may be increased by some 2 4 billions of dollars a year A second the work of restoration and rehabilitation can be accomplished within two decades A third this work can be accomplished by an annual investment equivalent to less than 3 per cent of our yearly retail sales of automobiles and accessories A fourth applied to rural populations in need of part-time jobs, this investment could provide 20 years of constructive work for people who, with their dependents, represent 1,000,000 people

Still another probability is that, although conditions and opportunities for early returns vary as between regions and localities, once forest lands are restored and improved they can—within areas from which much of our future population will come—assure more stable and better standards of living by providing *continuous* forest crops But this objective depends, as does insurance against a timber shortage of national proportions, on adopting and conforming to a more adequate forest policy and more adequate action programs than those we now have

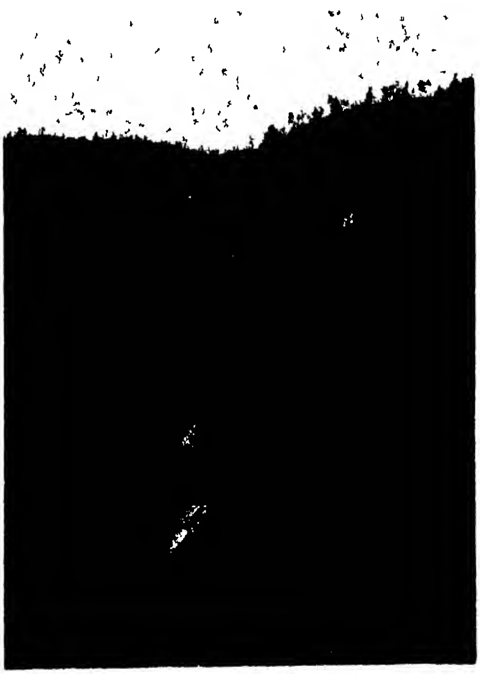
An adequate forest policy for the nation must recognize, according to Dr F A Silcox [1]

(*a*) That our 630 million acres of forest land are and probably always will be more valuable in forest growth than for plow land or any other purpose

(*b*) That this area must be adequately protected against damage or destruction by fire, insects, diseases and quick liquidation, and that on it adequate forest and other cover must where necessary be restored and maintained

(*c*) That, in addition, growing stock and productivity must be built up and maintained on the 462 million acres of commercial forest land

(*d*) That protection must be assured to private owners who comply with the nation's forest policy, and to those public interests that are inherent in all forest lands no matter who owns them



PLANTING PONDEROSA PINE SEEDLINGS

IN COLORADO TO GROW COMMERCIAL TIMBER AGAIN FOUR AND ONE HALF MILLION ACRES NEED REFORESTING IN NATIONAL FORESTS ALONE

(*e*) That research is basic to full and continuous use of all products and values and services that forest lands and their resources can render locally, nationally and through world-wide markets

(*f*) That since the forest resource is inextricably bound up with use of land for other crops, forest lands and their resources should be managed as integral

[1] Report of the Chief of the Forest Service, 1938

SELECTIVE CUTTING IN LODGEPOLE PINE
PROVIDES IMMEDIATE REVENUE, BUT LEAVES MANY TREES FOR FUTURE CROPS DEERLODGE NATIONAL FOREST, MONTANA

parts of a unified agricultural pattern contributing to local and national structures and to social as well as economic ones

President Roosevelt has suggested the need for an action program for forest lands His suggestions[2] include (1) public cooperation with private owners, (2) public regulation of cutting practices on privately owned forest land, (3) extension of public ownership and management

Public cooperation is essential because although private owners must in the public welfare conform to the forest policy for the nation, the public—through State and Federal Governments—must also recognize and redeem its responsibilities and obligations

Forest fires illustrate some of these public obligations and responsibilities

[2] Document No 539, dated March 14, 1938, addressed to the 75th Congress, 3d Session.

For although lightning sets forest fires, most of them are man-caused Witness the 1937 record Lightning, 31,000 human beings, 170,000 Most of the latter were the result of carelessness by campers, hunters and fishermen, but on the National Forests nearly one fourth were of incendiary origin

Since it should be possible to eliminate most man-caused fires, the first step in forest fire protection is prevention This is a field within which the Advisory Council on Human Relationships, recently created by the American Association for the Advancement of Science, will, it is hoped, offer expert advice and assistance

Forest fire protection also requires lookouts to detect forest fires, telephone lines and radio to report them, roads, trails, landing fields, tools and supplies, so crews can be equipped, get to and suppress fires without delay In all this,

BIG SAND LAKE IN THE LOLA NATIONAL FOREST, MONTANA
THERE ARE THIRTY NATIONAL FOREST PRIMITIVE AREAS WITHOUT ROADS, HOT DOG STANDS, ETC., THEY EMBRACE MORE THAN SEVENTEEN MILLION ACRES

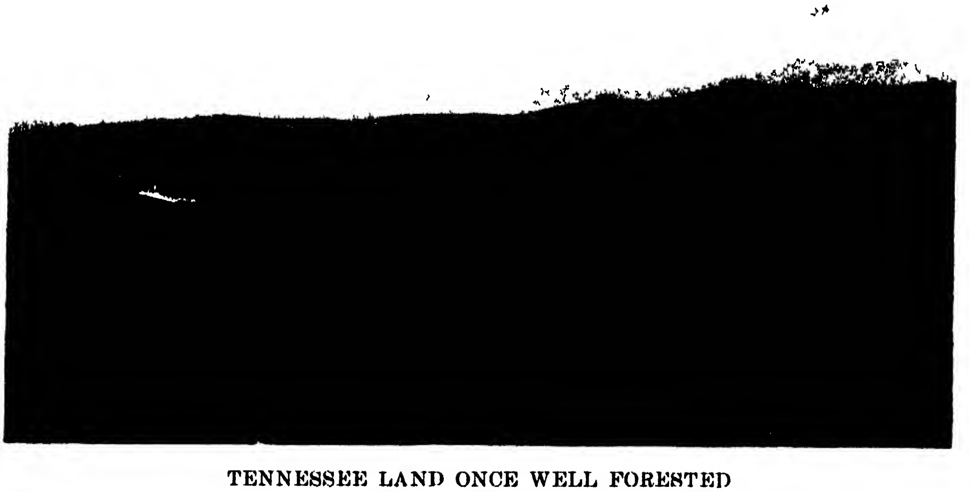
federal and state cooperation with private owners has brought real progress in the last 12 years The area of state and private land under organized protection increased to almost 302,000,000 acres, and the area burned decreased by more than 1,600,000 acres But nearly 70 per cent of the 1937 fires and 95 per cent of the area burned were on more than 182,000,000 acres that—for lack of adequate federal, state and private funds—are still outside organized fire protection districts

The forest inventory—on which industry as well as federal, state and local governments are drawing—is not yet completed, and there is also need for extension of public cooperation with respect to such things as forest credits, taxation of forest lands and research

Private credits to forest industries have in the past tended to force quick liquidation of the basic resource Public or publicly sponsored credits (like those administered by the Farm Credit and Federal Housing Administration) should—if extended to owners who comply with the nation's forest policy—help protect public interests and aid industry So might revision or modification of the present system of timber-land taxation, for it also tends toward quick liquidation practices

Most forest and allied research in the United States centers in and forms a major responsibility of the Forest Service Its object is to develop technical and economic bases essential for the intelligent use of forest land and its resources in private as well as public ownership This requires a wide range of information about hundreds of tree species occurring in an infinite variety of combinations and type conditions, of growing conditions in climate that varies from tropical to arctic

PULPWOOD THINNINGS IN 37 YEAR-OLD SHORTLEAF AND LOBLOLLY PINE IN ARKANSAS. EIGHT CORDS PER ACRE HAVE BEEN REMOVED, LEAVING 20 CORDS GROWING FOR MORE VALUABLE POLES, PILING, SAWLOGS



TENNESSEE LAND ONCE WELL FORESTED
EROSION, FOLLOWING KILLING OF VEGETATIVE COVER BY COPPER SMELTER FUMES, HAS ALSO EXTENDED INTO THE GRASS ZONE

and from rainbelt to desert; of many soils and many exposures; and of science in relation to social problems

Research has contributed extensively to progress in forest conservation, but there is still a large gap between what is known, what needs to be known and how it should be applied if one third of the land area of the United States is to contribute its fair share of raw materials, supply profitable and useful employment for thousands of workers in woods, mills and allied industries using wood, and play the role it should in regulating streamflow and controlling floods.

Private ownership is part and parcel of democracy as we know it, but forest lands have values and contribute services that are far greater to 130 millions of people than they are to the few thousands who now own most of the best of them Private initiative and public cooperation have brought worth-while advances in forest conservation, but exploitation is still the rule rather than the exception among operations on privately owned forest lands in the United States[3] And human exploitation still follows forest exploitation just as surely as night follows day

If public ownership is not acceptable as an alternative, these conditions point to some form of regulation of cutting practices And since neither in the United States nor in any other country has purely voluntary action succeeded in applying sustained yield management to forest lands generally, *public* regulation seems indicated

[3] According to *The New York Times* for February 23, 1939, George H Gibson of the Mosinee Paper Mills Company, speaking at a recent meeting of the National Paper Trade Association, said "There is no reforestation worthy of the name being practiced in this whole wide country of ours There will be none," he added, "until a terrific public opinion demands from this government that they take over and limit the cutting of the woods of the country not to exceed their annual growth "

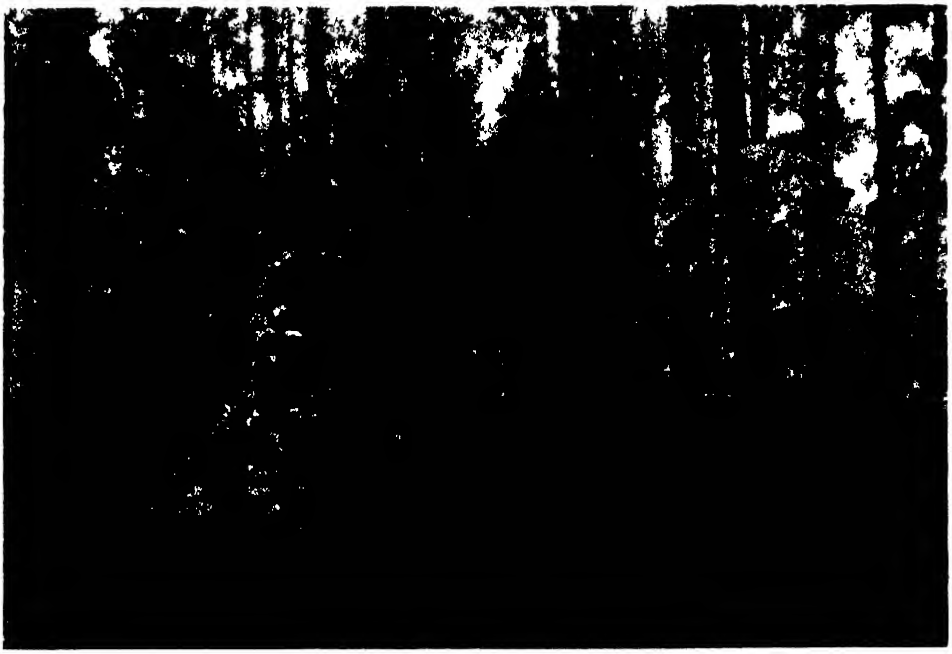
Dr. Silcox warns, however, that to safeguard our democratic pattern such public regulation "must come as a result of standards openly arrived at These standards," he says,[4] "must reflect local needs and conditions. They must be flexible and fair They must protect both local and nation-wide values and services, conserve broad public interests, safeguard those of dependent communities and private owners, provide for decentralized and understanding application, make court action unnecessary, except as a last resort, by assuring the right to arbitration and appeal "

Private ownership of forest lands antedates the Revolution, but public ownership and management are now established policies They already apply to community forests, state forests and National Forests

Community forests—there are about 1,500 of them in 20 or more states, with a total area in excess of 3 million acres—protect water supplies, provide opportunities for inspiration and inexpensive outdoor recreation, improve hunting and fishing, and grow timber for municipal and other uses Demonstrating that, managed on a cropping basis, the forest can be used for all these things, most of them illustrate essential differences between forests and parks They also afford local opportunities for replacing a public dole by worth-while work that increases the services and values derived by the public from these public properties

Like community forests, organized state forests are generally managed on a multiple-use basis They are, in this respect, distinct from state parks. Most of the 800 organized state forests in 41 states—with nearly 11 million acres of state-owned land—are not quite so near large centers of population, but many

[4] "A Federal Plan for Forest Regulation within the Democratic Pattern "



KENTUCKY LAND PLANTED TO YELLOW POPLAR TWO DECADES AGO
ONCE IDLE AND UNFIT TO PLOW, IT NOW PRODUCES NEW WEALTH

states plan to have them so well and widely distributed that the public will ultimately have ready access to them

National Forests are located on the flanks of the Appalachians from New Hampshire to Georgia, around the Great Lakes and headwaters of rivers like the Mississippi and Missouri, on the Great Smokies, in southern pineries and—between Canada and Mexico—on the slopes of the Rocky, the Cascade, the Sierra Nevada and the Coast Ranges They include nearly 176 million acres of federally owned land Established irrespective of state boundaries, these public properties are distinct from National Parks in that they are administered on a multiple-use basis, with use as well as renewal of all their resources and values

The national-forest system is interstate It offers striking contrasts between civilization and wilderness, industrial activities and pastoral, material values and spiritual ones More than 1,280 million feet of timber was harvested from it, under provisions that assure continuity of the forest stand, in 1938 It already provides a living for almost a million people, but it also provides recreation for 30 million each year It is home and refuge for most of our remaining big game, but also furnishes forage for more than 6,857,000 domestic live stock, and helps prevent floods and erosion It includes some 70,000 miles of fishing streams and more than 3,500 developed public campgrounds, yet it provides domestic water for 6 million city people And although they have 30 primitive areas embracing 17,000,000 acres, the National Forests also have a public transportation system that includes more than 138,000 miles of highways and roads and 153,000 miles of trails

The extent to which, with due regard to private ownership and initiative, community, state and federal ownership and management of forest lands might ulti-

mately be increased was placed before Congress, at its request, in 1920 and 1933 In 1934 this problem was analyzed by the National Resources Board, which suggested a long-time program involving some 190 million acres Field examinations by the Forest Service in 1937 suggest that community and state ownership and management might be extended to 48 million acres, and that federal ownership and management might be extended to 59 million acres Of the latter, 40 million are private land within boundaries of existing National Forests, 19 million acres, outside those boundaries, are vital to problems interstate in character and scope

Federal ownership—existing as well as proposed—poses the question of compensation to states and counties for loss of tax revenue The Federal Government has as yet no consistent policy with respect to this problem No compensation is made for millions of acres, yet for the National Forests 25 per cent of the gross receipts are returned to states and counties Based solely on current income, this provides little if any immediate returns from lands that, heavily cut by private owners, have been or may be purchased by the Federal Government. Fortunately there is recognition that this situation is unsatisfactory, and Senator Harrison, of Mississippi, has introduced legislation to remedy it

Civilizations the world over are dependent on land and water If nations are to be permanently prosperous and secure, these basic resources, and the living ones from which they spring, must be used wisely and well Forests are one of these resources It has been said that the chief causes of the decline of certain early civilizations were deforestation and denudation of hillside soil rather than changes of climate or attacks by bar-

FIELD AND FOREST IN WEST VIRGINIA

THIS VIEW OF NORTHFORK VALLEY, MONONGAHELA NATIONAL FOREST, ILLUSTRATES CLOSE RELATIONSHIPS BETWFEN FOREST AND PLOWLAND CROPS.

barians Whether or not this be true, it is known that the north coasts of Africa and Palestine were once well forested, but forests and civilizations there are at a low ebb now It is also known that China once had great forest wealth, but that to-day it is almost treeless and its people are forced to use dung for fuel

"Out of the forest came the might of America, wealth, and power, and men "[5] There is truth in this statement by Jenks Cameron, but out of those same forests have in large part come our distressed rural regions With minor exceptions these include 1,300 counties, half of all our farms, millions of acres of tax-delinquent land Index of average farm income is under 30 compared with 90 to 120 for typical corn belt counties Living standards are low, educational facilities meager There are 700 to 1,000 children under 5 years old for every 1,000 women of child-bearing age Undernourishment and pellagra are common

But 60 odd per cent of the land in these distressed regions is more valuable in forest growth than it is as plow land These lands once grew forests They have been abused, but forests can be restored on them Cropped instead of mined, new forest wealth can provide better standards of living for hundreds of thousands of families now in sore distress; and add to national security

What has happened to our forest lands and what is happening to them now indicate that it may be no light task for a nation to stop forest and human exploitation, and to provide affirmatively for forest and human rehabilitation Yet what has been done on the National Forests, and what is now being done on their own lands by leaders in forest industries, indicate that the job *can* be done And the values at stake seem to make it a worth-while one

[5] "Development of Governmental Forest Control in the United States" Published by the Johns Hopkins Press, 1928

THE BENLD METEORITE

By Dr. H. W NICHOLS

CHIEF CURATOR OF GEOLOGY, FIELD MUSEUM OF NATURAL HISTORY

THE meteorite which fell at Benld, Macoupin County, Illinois, on September 29 of last year is of unusual interest, as it is one of the few—there are only eleven of them—which are certainly known to have struck and damaged property At nine o'clock in the morning this meteorite crashed through the roof of a garage owned by Ed McCain and, after penetrating the roof of his Pontiac coupe, passed through the seat cushion and after striking and denting the muffler, rebounded and came to rest tangled in the springs of the seat cushion Two members of the Joliet Astronomical Society, Ben Hur Wilson and Frank M Preucil, secured the meteorite for Field Museum of Natural History in Chicago The meteorite, accompanied by the damaged parts of the car and roof, is now a part of Field Museum's important meteorite collection

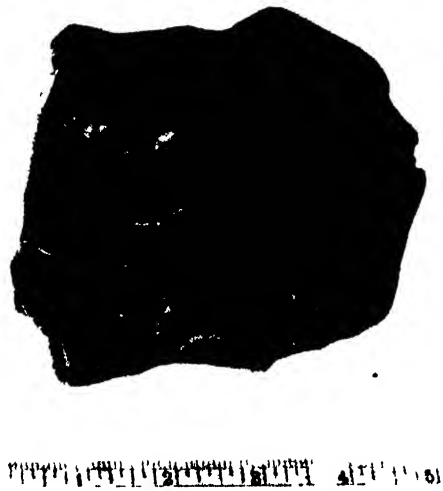
As reports of finds or falls of meteorites are almost invariably either without foundation or otherwise erroneous, Wilson and Preucil were naturally skeptical of the first reports Nevertheless, they entered into correspondence with Mr McCain and others in Benld which soon convinced them that the report might possibly be correct They were unable to visit Benld until October 29, more than a month after the fall, but found that Mr McCain had carefully preserved the meteorite and kept undisturbed the damaged car and garage At Benld they made unusually complete and competent notes and took numerous photographs Their observations have been published in full in *Popular Astronomy* [1]

[1] Ben Hur Wilson, *Popular Astronomy*, 46 548, 1939.

No one actually saw the meteorite fall, but the time was determined by the loud roar it made, which startled Mrs McCain and a neighbor and was heard less distinctly by several others The neighbor, Mrs Carl C Crumb, was in her back yard barely fifty feet from the garage She was startled by a great roar like that of a plane in a power dive This roar, which lasted only an instant, was followed by a sharp cracking sound like the breaking of boards She rushed into the alley expecting to find the roof or side of her barn crushed by a fallen plane, but found no damage nor was there any plane in sight She places the time between 9 00 and 9 10 o'clock in the morning Mrs McCain, in her yard but not as near the garage as was Mrs Crumb, also heard the roar but paid little attention, as she took it to be the sound of a passing plane No fumes, smoke or odor was detected by Mrs Crumb, but another neighbor, Mrs Lindy Brown, said she plainly detected an odor of sulfur (ozone?)

The fall of a meteorite is frequently accompanied by loud detonations, due to the meteorite bursting in the air No detonation was heard by Mrs Crumb or Mrs McCain and, as such explosions are very loud, if the meteorite burst in the lower part of its path the sound would certainly have been heard

The damage was not discovered until late, in the afternoon, when Mr McCain entered the garage to get his car The roof penetrated was of pine board with a "tar paper" cover The meteorite broke a hole, clean on the outside but splintered on the inside The hole is rectangular, about 4 by 5 inches in size It is slightly too small for the meteorite to pass



THE BENLD METEORITE

through, indicating that the board bent under the impact. The stone made a clean hole through the roof of the car. The hole through the seat is ragged, owing to the nature of the material. The dent on the muffler is only an inch deep, indicating that the stone had lost most of its energy before it reached the muffler. Where the stone came to rest after rebounding into the seat it was so entangled in the springs that they had to be cut before the meteorite could be removed. Examination of the cotton filling of the seat where it was in contact with the stone shows not the slightest indication of charring. This proves that the meteorite could not have been hot when it fell. This was to be expected, for those meteorites which have been picked up immediately after their fall have been only lukewarm. It is unusual to find one too hot to hold comfortably in the hand.

As two points in the path of the stone were known, the point where it penetrated the roof and the point where it penetrated the seat cushion, Wilson and Preucil were able, by the use of a surveying instrument, to determine with precision the azimuth and inclination of its path at the end of its travel. This is the first time such an accurate measurement has been possible for any meteorite. When the meteorite struck it was moving in a course 64° 26′ east of north in a path inclined 77° 31′ to the horizontal.

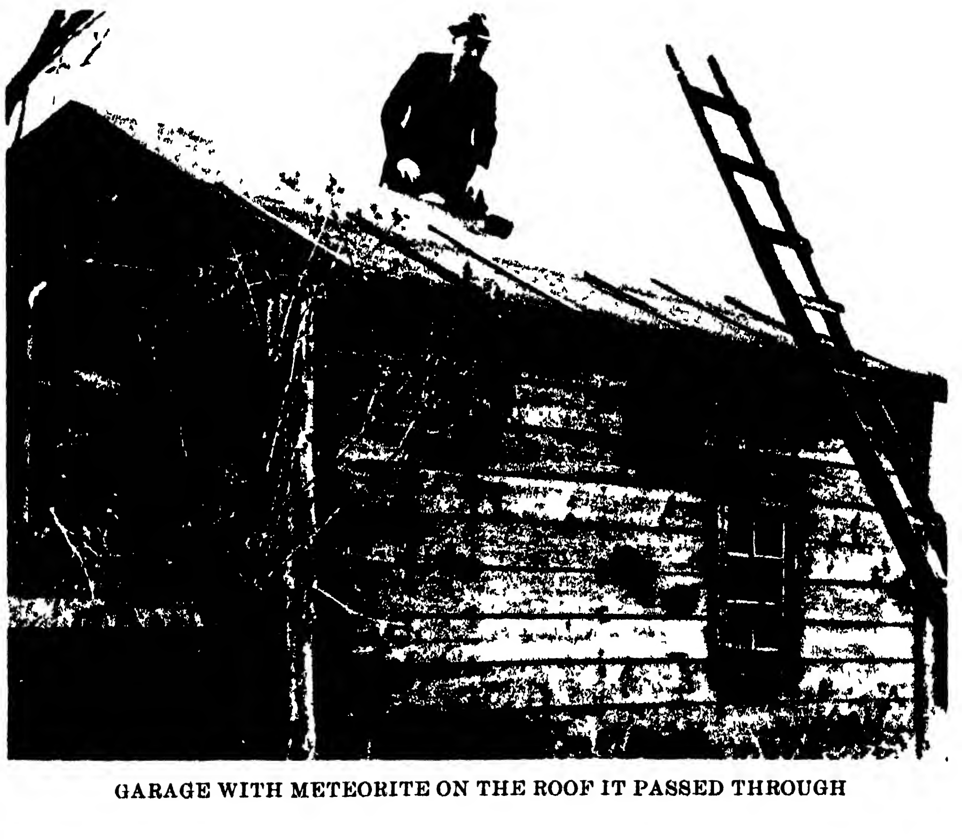
The meteorite is a roughly rectangular block 4½ inches long, 3½ inches wide and 3¼ inches thick. It weighs 1,770 grams, or about four pounds. It is a stony meteorite or aerolite. To which of the numerous sub-classes of aerolites it belongs has not yet been determined, but it will probably be classed as a veined gray chondrite. It is light gray in the interior with a porous granular texture and is covered with a thin black fused crust developed by friction during its passage through the air.

An account of the changes undergone by this meteorite during the few seconds of its passage through the air may be of interest. No one knows where or how meteorites originate. The older theories, such as that they come from volcanoes, the moon or sun, have long been discredited. A more recent theory that they are fragments of comets seemed for a time sufficient. This is the origin that seems most probable for the periodic swarms of shooting stars and for many of the other shooting stars which are meteoritic particles too small to pass through the atmosphere without being consumed, but there are reasons to believe that some other origin must be sought for the aggregations of meteoritic material which are large enough to reach the ground without being utterly consumed. There are indications that meteorites are fragments from larger bodies, but theories of their origin remain highly speculative. Some have orbits entirely within the solar system, others are visitors from outer space. If some one at a distance from Benld saw the meteorite as a passing meteor and noted its position and the direction of its

flight it may be possible to determine its orbit This has been done for a few other meteorites

Before the meteorite reached the air it was a gray body of unknown shape without the dark crust it now has It was much larger, for during its passage through the air it lost the greater part of its weight Wastage from friction during its passage through the air is so great that the Italian astronomer, Schiaparelli, computed that a stone meteorite, such as this, must have a diameter of at least eight feet if any portion of it is to reach the surface of the earth

The velocity of its approach was enormously greater than its speed when it struck the garage Meteorites striking during the morning hours collide with the earth head on so that the velocity relative to the earth is the sum of the velocities of earth and meteorite in their orbits. This velocity is of the order of forty-four miles per second If the Benld meteorite had retained this speed until it struck, the consequences would have been disastrous, for even if it had only its final weight of four pounds it would have struck a blow in excess of 2,000,000 foot tons Even the extremely rarefied upper atmosphere opposes so great a resistance to the passage of a body moving at such an enormous speed that its speed is rapidly moderated, and while it is still several miles above the surface its velocity has been reduced to that of a similar body falling under the influence of gravity alone This is the speed at which the acceleration of gravity is balanced by the resistance of the air In the case of the Benld meteorite it was probably between 400 and 500 feet a second Most of its lost energy of motion



GARAGE WITH METEORITE ON THE ROOF IT PASSED THROUGH

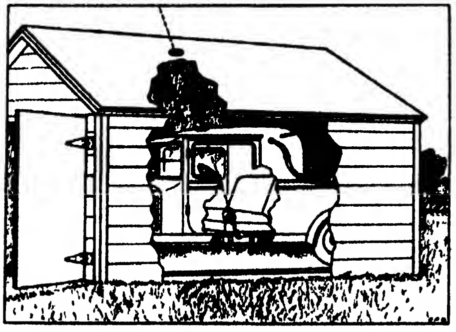


DIAGRAM OF METEORITE PATH

was converted into heat by friction between the surface of the rapidly moving meteorite and the air The surface became incandescent, melted and in part vaporized The rush of the meteorite through the air washed away the heated surface as fast as it softened or melted, bringing more of the meteorite to the surface to be in turn heated and washed away to trail behind as a luminous train Only a thin coating of the melted material remains to cover the meteorite with a dark crust

As a meteorite first appears high in the air as a glowing meteor, there appears to be a general belief that a meteorite must be intensely hot when it strikes But the

DAMAGE BY METEORITE

MAY BE REPRESENTED BY THIS OLD WOODCUT

friction-heated surface is washed away as fast as it forms, the body of the meteorite is intensely cold and there are only a few seconds available for heat to penetrate to the interior During the last few miles of its descent its velocity has been so reduced that the friction developed is no longer sufficient to heat the surface, the luminous phenomena disappear and the hot surface cools so rapidly that the meteorite is seldom more than lukewarm when it strikes, although a few have been too hot to be comfortably handled Reduction of velocity during its passage through the air is so rapid that enormous strains develop which cause many meteorites to burst The angular shape of the Benld meteorite suggests that it may have burst, but as no sound of explosion was heard at Benld, if it burst at all, it did so high in the air many miles from where it struck If it did burst, other individuals from it may be found possibly at a distance of several miles from where it struck

The fall of the Benld meteorite calls attention to the danger, ever present and not to be guarded against, of injury to person or property from falling meteorites Although this danger is always present the records show that peril from this source is so slight as to be negligible The late Dr Farrington, formerly head of the Department of Geology of Field Museum of Natural History and one of the world's leading authorities on meteorites, stated in his book "Meteorites "[2]

No meteorite fall has ever positively been known to have been destructive to human life Accounts purporting to describe such catastrophes prove on investigation to have come either from times or countries so remote that that they can not be verified Many accounts of such an occurrence come to us from earlier times and the scene here pictured probably illustrates destruction believed by an early artist to have been caused by meteoric stones falling from the skies But no well authenticated occurrence of

[2] O C Farrington, "Meteorites," p 28, 1915

DAMAGED CAR WITH ED McCAIN HOLDING METEORITE

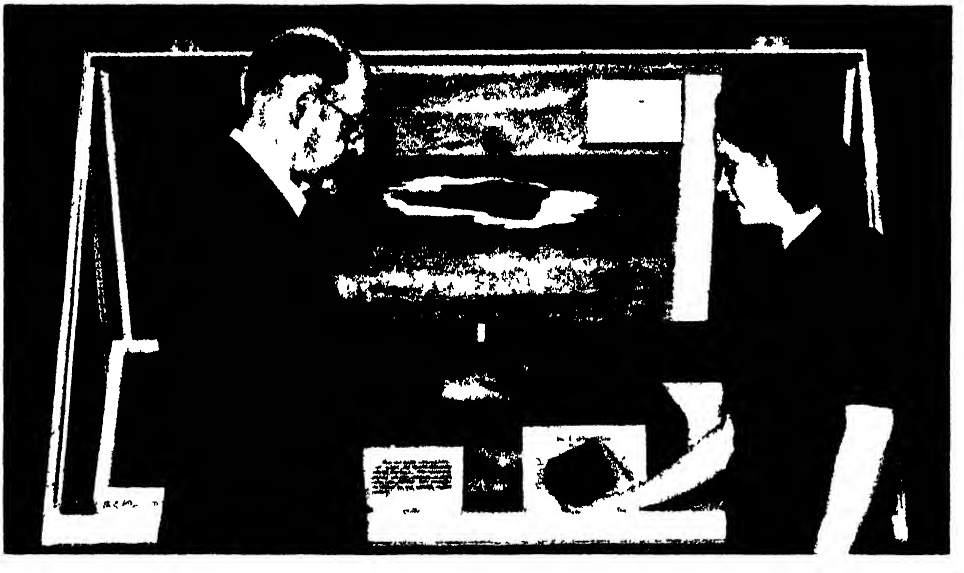
the sort is known Perhaps the most narrow escape which has ever been experienced was that of three children in Braunau at the time of the fall of that meteorite in 1847 This meteorite, an iron weighing nearly forty pounds, fell in a room where these children were sleeping and covered them with debris, but they suffered no serious injury Other meteorites have fallen near human beings but never have struck them so far as credible information goes That personal injury or death might be caused by the fall of a meteorite is entirely possible, in fact is likely to occur at some time It is remarkable that some falls, such for instance as the showers in Iowa which occurred in fairly thickly settled communities, should not have caused serious injury to the inhabitants

There are a few probable but not proven instances of animals being hit During the past 150 years during which records have been kept only eleven meteorites are certainly known to have penetrated buildings The first recorded damage to a building occurred at Barbotan, France, in 1790 Other damage to buildings was occasioned by meteorites which fell at Benares, India, in 1798, Massing, Bavaria, in 1803, Braunau, then in Bavaria, in 1847; Aussun, France, in 1858, Pillistfer, Lativa, in 1863, Kilbourn, Wisconsin, in 1911, Baxter, Missouri, in 1916, Kurumi, Japan, in 1930, Yurtusk, Ukraine, U S S R, in 1936, and Benld, Illinois, in 1938 Fragments of eight of these are in the collection of Field Museum The collection also has a roof board penetrated by the meteorite which struck a barn in Kilbourn, Wisconsin, on June 16, 1911 The stone passed through three thicknesses of shingles, a hemlock roof board and the plank floor of a hay loft It then glanced against the side of a manger and buried itself two and one-half inches deep in the clay floor of the barn There is also the branch of a tree, barked by a meteorite which fell in Andover, Maine, on August 5, 1908. There are also a few instances where damage by meteorites seems probable but can not be proven A recent example is the fall of a meteorite in Pennsylvania among the cattle on a farm Later one of the cows was found to be seriously injured, as if it had been struck by the meteorite It is

probable that the meteorite struck the cow a glancing blow, but as there are many ways in which cattle can be injured this conclusion can not be accepted as absolutely certain The frequent newspaper accounts of injury are always investigated and prove with few exceptions to be without foundation Some of them are absolutely baseless, others are the results of mistaken interpretation of the cause of the damage, and others are deliberate fakes An example of mistaken interpretation was the case that came to the attention of Field Museum many years ago of a woman while in her back yard being struck on the head by a small meteorite The alleged meteorite proved to be an ordinary pebble and an investigation showed that, as the woman was much disliked by the children of the neighborhood, it is probable that she was hit by a stone thrown by one of the children An example of a deliberate hoax is a report from Crawfordsville, Indiana, where it was claimed that a meteorite struck a Ford car and passed through its hood Investigation showed that the damage was occasioned by the accidental discharge of a gun and a meteorite hoax was invented by boys to avoid liability for the damage.

A calculation by Dr H H Ninınger, of the Society for Research on Meteorites,[3] shows how exceedingly slight is this danger from falling meteorites He found that for the 125 years preceding 1925 there were, in twelve European and American countries, for which fairly good records have been kept, 287 witnessed falls, from which 129,349 individual meteorites have been recovered The area of the countries involved is 7,205,503 square miles These figures show that one meteorite from a witnessed fall fell for each fifty-five and one-half square miles of surface But many meteorites fall unseen Dr Nininger, arbitrarily assuming that ten times as many meteorites fell as were reported, a reasonable figure, estimates that in 125 years one meteorite fell for each five and one-half square miles When we consider how small an area is covered by living human beings it is not surprising that no one has as yet been

[3] H H Nininger, "Our Stone Pelted Planet," p 78, 1933



METEORITE WITH DAMAGED PARTS OF CAR AND GARAGE IN FIELD MUSEUM

injured. The area covered by buildings is of course larger but yet so small that the wonder is not how few but how many buildings have been struck.

It is only the exceptional meteorite, one out of many millions, that is large enough for any part of it to survive the wastage of its passage through the air. When such a meteorite strikes, its size and velocity have been so greatly reduced that the impact is relatively harmless. Even more exceptional are the few that have made the meteoric craters like that at Canyon Diablo, Arizona, which is three quarters of a mile in diameter and 570 feet deep. These are so enormous that they are little impeded by the resistance of the air, and when they hit they excavate huge craters like those from the explosion of military mines. Only eight of these are certainly known to have fallen in recent geological times. There are a number of other craters the origin of which is disputed, but adding these and probable future finds to the eight will not more than double the number.

The earth is daily bombarded by millions of meteorites so small that they are completely consumed in the upper air, miles above the solid surface. These are perceived only as luminous trails of shooting stars and meteors. Most of these trails are so faint that they may be seen only through powerful telescopes. The great majority of them weigh from a few ounces to a fraction of a grain, but even a particle weighing less than a grain moving with the original velocity of a meteorite would pass completely through a human being. We would have, were it not for our atmospheric protection, instead of an occasional trivial damage, as exemplified by the Benld meteorite, an aerial bombardment so severe that animal life could not exist except in the depths of the sea.

THE ORIGIN OF IGNEOUS ROCKS AND THEIR MINERAL CONSTITUENTS

By Dr J. F. SCHAIRER
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SINCE the beginnings of human history, man has noticed the rocks on the surface of the earth and wondered whence they came Rocks originating from hot, molten materials were observed in very early times in the Mediterranean region Flows of hot lava poured from active volcanoes, devastating the countryside and terrifying the inhabitants When these lavas cooled, new rocks, which were called igneous or fire rocks, covered the areas of the flows Also, hot volcanic ash and breccia were blown from the volcanic craters and showered on the neighborhood Hot springs, fumaroles and solfataras showed that in other places heated materials came from within the earth But only during the past century and a half have scientists obtained a clear picture of the nature of the processes and of some of the physical and chemical principles which underlie the formation of the igneous rocks

NATURE OF ROCKS

A rock is usually an aggregation of minerals, but this is not a broad enough or a wholly correct definition Rocks may be composed entirely of minerals or entirely of glass or partly of both A mineral is a chemical element or compound which occurs in nature Glasses are merely chilled molten masses which have not crystallized into one or more definite minerals In ordinary usage, a rock is something hard and firm, but in geology the word rock does not have this limitation, for a soft layer of volcanic ash or dust is also a rock A rock is one of the integral components of the earth's solid shell Rock of a particular kind implies a certain constancy of chemical and mineral composition Thus, a large or small mass of granite is a recognized kind of rock, but a chance filling of a mineral vein by variable amounts of ore minerals is not accepted by petrographers as forming a definite rock According to ordinary geological usage, a particular kind of rock must possess definite boundaries and show by its relations to other rock masses that it owes its existence to definite geological processes The size of a rock mass is not important, for a seam or dike of granite or basalt cutting rocks of other kinds may be as thin as cardboard or a mile in thickness

Rocks may be divided into three general classes according to their mode of origin (1) *igneous rocks,* derived from a molten magma, (2) *sedimentary rocks,* derived from detrital material, and (3) *metamorphic rocks,* formed from the other two classes by physical or chemical processes

The igneous rocks are the primary rocks of the earth's shell, because from them *all* other rocks have been derived by weathering, disintegration, transportation, chemical or physical changes and other generally similar processes In a broad sense, the chemistry of the igneous rocks is the chemistry of the earth's primary crust

ROCK MAGMAS

The ultimate source of an igneous rock is its parent magma—a molten solution of complex silicates with smaller amounts of the less abundant chemical elements and compounds of the earth's mass Rocks are formed from this parent magma by a crystallization, in whole or in part, of this molten solution Minerals do not crystallize from a magma in the order of their fusibility, but follow much

more complex laws which we shall discuss later The complex crystallization processes by which a magma may yield many different kinds of igneous rock is known as magmatic differentiation This process follows definite physical and chemical laws operating on a large scale in the earth

Many of the ore deposits of the world are closely connected with the igneous rocks In order to outline the process of their development, let us assume that there is a large body of molten magma in a subterranean reservoir On cooling, crystallization begins and a large part of the mass crystallizes to form igneous rocks By reason of selective crystallization, those chemical constituents which are present in the largest amount or are most insoluble are first removed from the solution to form igneous rocks Gradually there is a concentration of rare or more soluble constituents and of water and gases in the residual solution Valuable metals concentrated in this way may be later deposited in veins or fissures in the already cooled igneous rocks or in the surrounding rocks, thus producing important ore deposits

In volcanoes and volcanic fissures we often see molten lavas which actually reach the surface of the earth A picture of the lava pit at Kilauea in Hawaii is given as Fig 1 We know, however, from geological studies all over the world that very much larger amounts of molten magma come up from the interior of the earth into its outer zones, and there cool slowly and crystallize without ever actually reaching the surface The rocks formed from these deep-seated magmas are not exposed generally until after many millions of years, when the overlying rocks have been removed by erosion

Chemical Composition of the Igneous Rocks

Of the ninety-two fundamental elements known to chemists, ten make up about 99 per cent of the igneous rocks

(*Photo by E S Shepherd*)

FIG 1 VIEW INTO THE CRATER, HALEMAUMAU, AT KILAUEA, HAWAII, SHOWING MOLTEN LAVA.

FIG 2 THIN SECTION OF IGNEOUS ROCK (DIABASE) SHOWING CRYSTALS OF PLAGIOCLASE, AUGITE AND MAGNETITE

In the minerals of the igneous rocks, as in the magmas, most of the elements occur combined with oxygen Magmas are silicate solutions, that is, molten masses of the various oxides of the metals combined with silica (oxide of silicon), SiO_2 The average composition of the igneous rocks expressed as oxides is given in Table I

TABLE I

AVERAGE COMPOSITION OF IGNEOUS ROCKS

Oxides	Percentage
Silica (SiO_2)	59 12
Alumina (Al_2O_3)	15 34
Ferric (Fe_2O_3)	3 08
Ferrous (FeO)	3 80
Lime (CaO)	5 08
Soda (Na_2O)	3 84
Magnesia (MgO)	3 49
Potassia (K_2O)	3 13
Water (H_2O)	1 15
Titania (TiO_2)	1 05
Phosphoric (P_2O_5)	0 30
Manganous (MnO)	0 12
All others	0 50
	100.00

In considering the principles involved in the origin of the igneous rocks, we shall confine ourselves to the chemistry of the first ten oxides of Table I

Mineral Composition of the Igneous Rocks

Most of the igneous rocks are made up of crystalline chemical compounds, called minerals A knowledge of these minerals is essential before any attempt is made to trace their origin The petrologist, through a study of thin sections (see Fig 2) of a large number of rock types and the relations of rocks to each other in the field, has acquired a large amount of information concerning rocks and minerals which must form the background of any inquiry into the physical and chemical processes involved in their origin

One igneous rock may consist of grains so large that the individual minerals may be easily distinguished and identified, whereas in another the grains may be so small as to preclude identification except with a microscope or x-rays The mineral grains may be of uniform size or the rock may consist of a few large crystals embedded in a ground mass of tiny mineral grains The petrologist obtains clues to events in the history of the rock from such textures or from larger-scale zonings in rock series For example, in certain of the lavas most of the rock is a black glass with a few crystals of the mineral pyroxene, so oriented in the glass as to indicate the flow lines of the moving lava stream Other bodies of igneous rock show signs of zoning, indicating that certain minerals have settled toward the bottom or floated upward in the lava stream or magma chamber Etched or corroded crystals indicate that minerals, stable at one stage, became unstable in a subsequent stage and were redissolved, in whole or in part, or transformed to other minerals. These examples and many other such observations on minerals and rocks suggest the nature of the physical and chemical processes that were in operation in their formation

The most important and common minerals of the igneous rocks are given in Table II.

The Problem of Origins

We have been concerned thus far with general questions about rocks and their

TABLE II

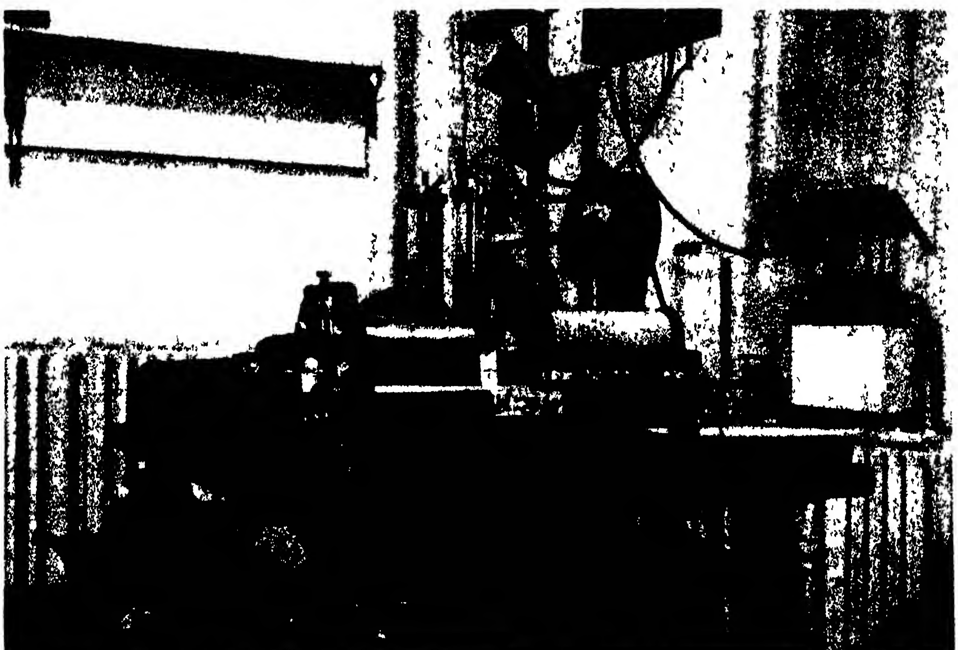
COMMON MINERALS OF THE IGNEOUS ROCKS

Minerals	Principal components
Olivines	Mg_2SiO_4 and Fe_2SiO_4
Pyroxenes	$CaSiO_3$, $MgSiO_3$ and $FeSiO_3$
Amphiboles and micas	Complex Fe, Mg and Ca silicates
Feldspars	
Lime feldspar	$CaAl_2Si_2O_8$
Soda feldspar	$NaAlSi_3O_8$
Potash feldspar	$KAlSi_3O_8$
Quartz	SiO_2

sources, particularly the igneous rocks and their mineral constituents; let us now consider more specific problems bearing on the origin of these materials When a magma crystallizes to form an igneous rock or rocks, at what temperature does this crystallization process begin? Does crystallization begin at the same temperature in two magmas of different chemical composition? Do all minerals separate simultaneously? If not, what is their order of crystallization? Does a magma of a particular chemical composition always yield the same rock or rocks? If not, what chemical and physical processes operate to yield the different rocks?

Many questions arise concerning the individual minerals found in the igneous rocks Do minerals always have constant chemical compositions? If not, what factors influence the composition of certain minerals? What is the origin of zoned crystals (crystals whose optical properties under the microscope indicate concentric zones of different but related chemical composition)? Why do certain minerals in the igneous rocks appear corroded as if they had crystallized and subsequently were partly dissolved? Why do certain minerals show reaction rims (mineral grains with surrounding rims of different minerals)?

These inquiries are but a few examples of the problems that engage the attention of the scientists who are devoting their efforts to investigating the nature and origin of the physical materials of the earth We shall attempt to show how



(*Photo by C J Ksanda*)

FIG. 3 X RAY GONIOMETER USED TO STUDY CRYSTAL STRUCTURE AT THE GEOPHYSICAL LABORATORY

(*Photo by J Harper Snapp*)

FIG 4. A HIGH TEMPERATURE INSTALLATION AT THE GEOPHYSICAL LABORATORY, SHOWING FURNACES, THERMOCOUPLES, POTENTIOMETER, TEMPERATURE REGULATORS, AND MICROSCOPE USED IN STUDYING MELTING RELATIONS OF SILICATES

these problems have been attacked and what progress has been made toward a better understanding of the origin of the igneous rocks and their minerals

Cooperative Laboratory Studies

Field geologists, by examining igneous rocks in various parts of the world and their relations to one another and to the surrounding rocks, have accumulated a large amount of observational information. Petrographers, by studying these same rocks in detail in thin sections under the microscope, have obtained a large number of facts concerning the more minute structures and the relationships of the several minerals to one another. Analytical chemists have supplied information about the chemical compositions of the rocks and of their mineral components These various kinds of information about igneous rocks raise questions concerning the nature of the processes by which they have been formed that point the way to laboratory experiments for determining the fundamental behavior of silicate solutions of the ten chemical oxides that make up 99 per cent of igneous rocks.

Although we are considering the chemistry of only ten chemical substances, the problem is very complex, for there is an almost unlimited number of possible combinations of these ten materials. If we are to have success we must break up the problem into smaller units and solve the rela-

tions of the ten substances to one another by isolating the variables and investigating them individually.

An experimental study, in the laboratory, of silicate solutions comparable to the rock magmas at high temperatures and pressures requires the combined efforts of various experts. High temperatures and pressures must be produced by some means and accurately measured and controlled. Careful work of an entirely different kind is necessary to produce and control the chemical compositions of the artificial rocks. The petrographic microscope is essential in order to identify the artificial minerals that are produced and to follow their changes in chemical composition. The use of x-rays is important in order to identify very finely crystalline phases and to elucidate the laws of crystal structure, polymorphic forms (two or more crystal forms of the same chemical substance) and solid solutions (continuous variation or variation within definite limits of the chemical composition of a single crystalline substance). A photograph of the x-ray goniometer used for this purpose is given in Fig 3 Delicate physical methods are required for measuring the heat changes that occur when an ounce or a ton of a mineral melts or crystallizes.

In the Geophysical Laboratory of the Carnegie Institution of Washington, such a group of geologists, petrologists, physical chemists and physicists has been collaborating for more than thirty years. Over a thousand articles describing these investigations have appeared in scientific journals. The program, under the directorship first of A L. Day and later of L H. Adams, has been carefully planned and executed. By proceeding from the simple to the complex and solving variables one by one, very substantial progress has been made toward the solution of the problem of rock formation as a whole. The experimental investigation of rocks is a conspicuous example of progress in a difficult field through cooperative effort. Here, I shall confine my remarks to the studies of silicate melts at high temperatures, my particular field of interest, without in the least minimizing the importance of pressure This important factor has been already considered in detail by my colleagues L H. Adams[1] and R. E. Gibson[2]

Rock-forming Silicates at High Temperatures

Before proceeding with a study of a complex solution of ten different rock-forming oxides we required some knowledge of the effect of temperature on the behavior of the separate substances. Silica (SiO_2), the most abundant of these oxides, occurs naturally in four different crystalline forms whose relations to one another with respect to range of stability were not known and had to be determined The melting point of SiO_2 was known to be fairly high (considerably above the melting point of iron), but no exact value had been determined One of the first problems to be solved was the production and accurate measurement of high temperatures up to the melting point of platinum (1755° C) After the establishment (by A L. Day and others) of an absolute temperature scale for high temperatures by means of the nitrogen thermometer, measurements of the exact melting points of certain silicates were possible

In place of natural rocks and minerals, artificial ones were prepared from pure chemicals by a series of meltings in electric furnaces. With these simple synthetic mixtures, a careful control of chemical composition was possible. A natural specimen of even a simple mineral like quartz (SiO_2) usually contains small amounts of other minerals as microscopic inclusions which can not be conveniently separated and which often serve merely to confuse the investigator. Since the

[1] L. H. Adams, Sci. Monthly, 44: 199–209, 1937.

[2] R. E. Gibson, Sci. Monthly, 46: 103–119, 1938.

fundamental behavior of a substance is primarily due to its chemical composition, artificial rocks or minerals made from pure chemicals are to be preferred to natural materials, which contain small amounts of undesirable impurities.

Early studies of the melting relations of minerals were made by means of heating or cooling curves, a method very successfully applied by the metallurgist in his study of metal alloys Most silicates, because of their low heat conductivity and their slow rate of chemical reaction, gave either no results or relatively poor ones by this method With the development of the method of quenching it became possible to obtain accurate and reliable data on the melting relations of many of the rock-forming silicates

Method of Quenching

In the method of quenching, a particular mixture of pure chemicals is placed in a platinum crucible, platinum being used because it is inert chemically and has a high melting point (1755° C) This mixture is heated above its melting point several times, with intermediate crushing and powdering, until it is very uniform in composition When removed from the hot furnace, it is cooled quickly by plunging it into cold water Most silicates, when so treated, have the property of "freezing" to a glass, which is merely a supercooled liquid that has not crystallized After this glass has been powdered it is examined under the petrographic microscope in liquids of known indices of refraction When it is absolutely homogeneous, that is, uniform in chemical composition, all glass grains have exactly the same index of refraction A portion of this uniform material is crystallized by maintaining it at a suitable temperature until crystals form, which may be a period, depending on the chemical composition, ranging from five minutes to five years The crystals are identified by means of their optical properties in polarized light under the petrographic microscope With silicates it is usually advantageous to have crystals (small in size so they may come to equilibrium with the liquid rapidly) present, because of the sluggishness of chemical reactions in silicate-melts and their tendency to supercool

We are now ready to determine what happens to this particular composition at any selected temperature. A small sample of the crystallized glass is placed in a tiny platinum envelope. By using a small amount we avoid difficulties of different temperatures within the charge The envelope is hung next to the junction of a platinum—platinum 90 per cent, rhodium 10 per cent thermocouple which is placed at the "hot point" or center of the zone of uniform temperature in a platinum-wound electric furnace In order to read the temperature we use a potentiometer and thermocouple, a combination which is merely an electrical thermometer. The temperature is controlled and kept constant within 2° C by means of a special electrical thermostat developed by physicists at the Geophysical Laboratory The charge is suspended by means of a fine wire across two heavy platinum wires. When the chemical reaction has gone to completion and holding for a longer time produces no further change, the equilibrium is "frozen" by dropping the tiny platinum envelope into cold mercury This is accomplished by melting the supporting wire with a heavy electric current Cooling is so rapid during quenching that there is no time for chemical change to take place, and a "frozen" sample of the material is obtained Any liquid that was present at the temperature of the experiment will be glass, and any crystals that were present in the liquid may be identified by their optical properties under the microscope By a series of such quenching experiments on a particular composition, the beginning

of melting, completion of melting and temperature of formation or disappearance of any particular kind of crystals—in other words, any phase change—may be determined. By selecting a series of related chemical compositions, preparing such compositions and making the necessary quenching experiments, much systematic and valuable information may be obtained concerning the complicated processes of crystallization.

In summary, the investigation of melting phenomena in silicate-melts consists of holding a small sample in a furnace at a fixed temperature, which is measured by means of a thermocouple and potentiometer and controlled to $\pm 2°$ with an electrical thermostat. After adequate time has been given for chemical reactions to proceed to completion at the fixed temperature, the equilibrium mixture is "frozen" by very rapid cooling. The nature of the sample at the temperature of the experiment is determined by a microscopic examination of the quenched charge Fig 4 is a photograph, taken in the Geophysical Laboratory, which shows these necessary pieces of equipment for determining melting relations in silicates

Phase Equilibrium Diagrams

Phase diagrams are graphs used to express the facts of equilibrium in heterogeneous systems—systems involving equilibrium between two or more phases What do we mean by the words phase, equilibrium and silicate system?

A chemical system is said to be homogeneous when all parts of the material under consideration possess the same chemical and physical properties. It is said to be heterogeneous when it is composed of two or more homogeneous parts separated by physical and sometimes chemical discontinuities The homogeneous parts of a heterogeneous system are called phases. For example, at its freezing point liquid water is in equilibrium with solid ice and water vapor. There are three phases present: one liquid phase, one solid phase and one gaseous (vapor) phase in the one-component system, water (H_2O).

The concept of phases is readily understood, but somewhat greater difficulty is usually experienced when we come to consider what is meant by the term component The components of a system are not synonymous with the chemical elements or compounds present (constituents of the system), although either or both may be components By the components of a system we mean only those constituents whose concentration can undergo *independent* variation in the several phases In the system previously chosen as an example of phases, the number of constituents taking part in the equilibrium is only one, the chemical substance water (H_2O) Hydrogen and oxygen, the constituents of water, are not components because they are not present as such but are combined chemically in definite proportions as H_2O, and their amounts, therefore, can not be varied independently As components of a system the smallest number of independently variable constituents are chosen Equilibrium is not dependent upon the actual amounts of the phases, but only on the fact of their coexistence

The underlying law of equilibrium in heterogeneous systems is the phase rule developed mathematically from thermodynamic principles by the great American scientist J Willard Gibbs during the last half of the nineteenth century Its use in its present form is due to H W. Bakhuis Roozeboom, the Dutch chemist, who at the suggestion of van der Waals applied Gibbs's phase rule to a study of actual chemical systems and used it as a guiding principle in predicting the conditions at equilibrium This rule for a system in equilibrium may be very concisely summarized in the form of the equation

$$P + F = C + 2 \text{ or } F = C + 2 - P,$$

where P is the number of phases in the system at equilibrium, F is the number

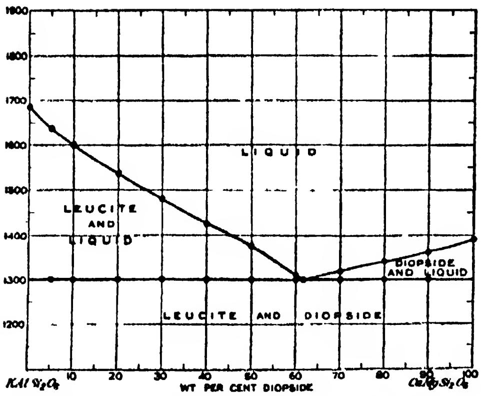


FIG. 5. EQUILIBRIUM DIAGRAM FOR THE SYSTEM, LEUCITE—DIOPSIDE. (BOWEN AND SCHAIRER)

of degrees of freedom (the variability), and C is the number of components. The number of degrees of freedom is the number of the variable factors (temperature, pressure and concentration of the components), which must be fixed in order that the condition of the system shall be completely defined. It should be noted, however, that the phase rule tells us the condition of the system *when equilibrium is reached,* but does not tell us anything

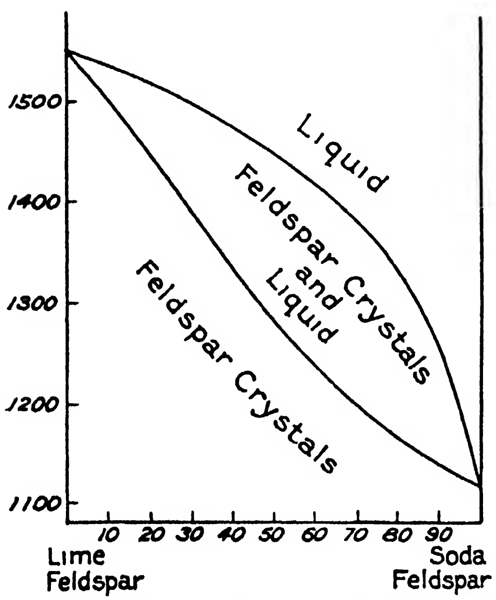


FIG. 6. THE SYSTEM, LIME FELDSPAR—SODA FELDSPAR (PLAGIOCLASE FELDSPARS). (BOWEN)

about the rate of attainment of equilibrium. For the system, water, at its freezing point, already used as an example, we have one component and three phases, and we find, by substituting these values in the equation, that $F=0$. In other words, the coexistence of these three phases in the system, water, is possible only at a fixed temperature and fixed pressure; that is, the system is invariable. If we raise the temperature the ice melts and we lose the solid phase, ice If we lower the temperature the water freezes to ice and we lose the liquid phase, water.

Binary Systems

First, let us examine the simpler melting relations found in two-component (binary) systems of rock-forming substances As type I, we shall select a mineral pair, leucite—diopside, showing the simple eutectic relation (that is, no solid solution) A binary phase equilibrium diagram for this system is given as Fig. 5 We notice that temperature is plotted in the vertical direction and composition in weight per cent in the horizontal The actual compositions, on which measurements were made, are designated by solid circles Each component has a congruent melting point, that is, the solid melts sharply, at a definite temperature, to a liquid of the same chemical composition as the crystalline solid We notice that pure leucite has a high melting point, 1686° C, and that, as we add diopside to leucite, the temperature of completion of melting (liquidus curve of leucite) is lowered; and similarly as we add leucite to diopside (liquidus curve of diopside), the temperature of completion of melting is lowered The point at which the two liquidus curves intersect is the eutectic point, and its temperature (1300°) is called the eutectic temperature. All compositions in the system, except the pure components themselves, become completely solid on cooling only at the eutectic temperature, and either leucite or diopside sepa-

rates first, depending on which side of the eutectic the selected composition lies, and is joined by the second solid phase and becomes completely crystalline at the eutectic temperature. Conversely, on heating, the first liquid appears at this eutectic temperature in all compositions except the pure components. The only two solid phases in the system are *pure* crystals of leucite and *pure* crystals of diopside The eutectic temperature is lower than the melting point of either pure component.

As type II, we shall select a mineral pair that show a complete series of solid solutions We shall use the well-known plagioclase feldspars, so common in many igneous rocks, as an example The diagram for anorthite (lime feldspar)—albite (soda feldspar) is given as Fig 6 The liquidus curve, we may observe, looks quite different from the eutectic type (type I). By the addition of albite to anorthite the temperature of completion of melting (liquidus) is continuously lowered; or conversely, by the addition of anorthite to albite its liquidus is continuously raised. We see, also, that there is no single temperature comparable to the eutectic temperature of type I (the one temperature at which *all* mixtures begin to melt on heating or become completely solid on cooling), but that each mixture begins to melt at a different temperature (solidus curve, lower curve in Fig 6)

This type of diagram is most interesting to the student of igneous rocks, because so many of our rock-forming minerals are solid solutions, either of this simple type or of much more complex types. The olivines, pyroxenes, amphiboles and feldspars are outstanding examples. From this type of diagram, we may see why zoned crystals are found in rocks. Let us examine the crystallization of a typical mixture

We shall follow the crystallization process of a mixture of the composition 50 per cent. lime feldspar 50 per cent. soda feldspar, assuming that cooling is slow enough so that equilibrium is reached, at all times, during the crystallization process This composition is represented by the point x (Fig. 7), which is at a high temperature and completely liquid. On cooling, the first crystal appears at 1450° (temperature of point a) and its composition is represented by the point b, a composition much richer in the lime feldspar component than is the composition of our chosen mixture On further cooling, there is a simultaneous change in amounts and in

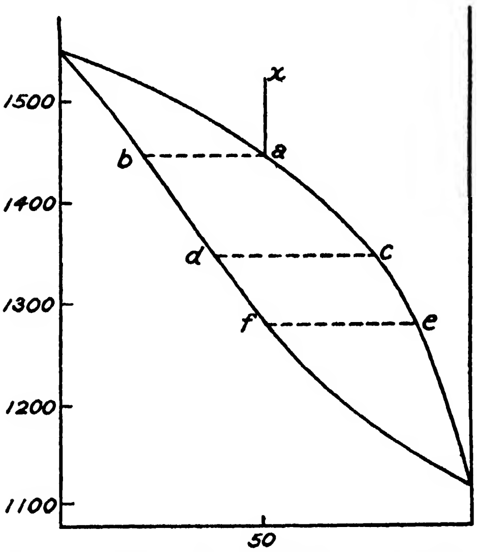


FIG 7 CRYSTALLIZATION PATHS IN THE SYSTEM, LIME FELDSPAR—SODA FELDSPAR.

chemical composition of *both* the crystals and the liquid. When the temperature of the flat dc is reached, the crystals have moved in composition from b to d (have become progressively richer in soda feldspar) and the liquid has moved in composition from a to c, but there is much less liquid present. When the temperature has reached 1287° (temperature of point f), the mixture becomes completely solid, and the crystals, which have moved in composition from d to f, have the composition 50 per cent. lime feldspar 50 per cent. soda feldspar, the same composition

as *x*, our chosen mixture. The last bit of liquid had the composition *e* Because of the continuous reaction between both crystals and liquid during crystallization, this is called a continuous reaction series Our chosen mixture crystallized to yield crystals of the same composition, but note what an involved course the path of crystallization followed

In the crystallization of a magma to form igneous rocks, cooling is often too rapid to allow equilibrium to be reached, and the first crystals to appear are not afforded sufficient time to react with the liquid Thus they become coated with a

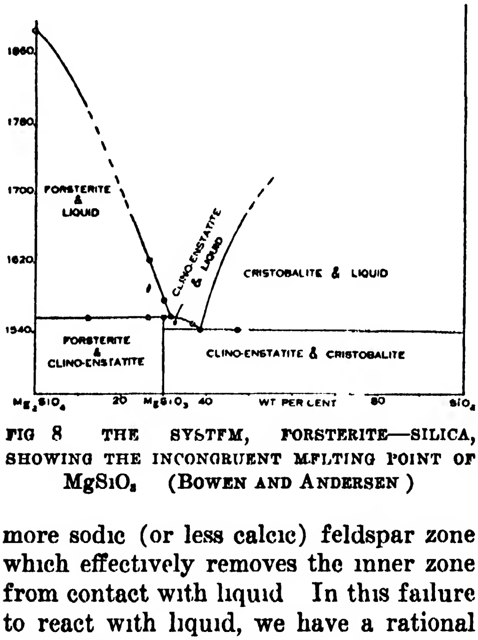


FIG 8 THE SYSTEM, FORSTERITE—SILICA, SHOWING THE INCONGRUENT MELTING POINT OF $MgSiO_3$ (BOWEN AND ANDERSEN)

more sodic (or less calcic) feldspar zone which effectively removes the inner zone from contact with liquid In this failure to react with liquid, we have a rational explanation of zoning in plagioclases Sometimes reversal of zoning is found that indicates an abrupt change in conditions during crystallization We can not attempt to go into all the possibilities, but wish merely to indicate how processes of mineral growth can be explained when we apply the information to be read from such phase diagrams

We have reason to believe that in the crystallization of magmas, fractional crystallization is very important in yielding the great diversity of rock types Since the crystals of feldspar continuously react with the liquid present, if they are removed by floating or sinking in the liquid or are effectively removed—at least in part—by zoning, the whole course of crystallization is changed and the composition of the residual liquid moves to the right (Fig 7) With a great amount of fractionation, the residual liquid will approach pure soda feldspar in composition. No natural magma is so simple as this feldspar diagram, but similar principles apply in the many more complicated diagrams which more nearly approach rock compositions

Another type of binary diagram, which involves reaction between crystals and liquid, is chosen as type III In Fig 8 we have the system, forsterite (Mg_2SiO_4)—silica (SiO_2), with the compound clinoenstatite ($MgSiO_3$), which has an incongruent melting point Certain complications at the high silica side of the diagram have been deliberately omitted. When crystals of $MgSiO_3$ are heated, melting begins at 1557° C with a separation of crystals of Mg_2SiO_4 (incongruent melting) The material becomes completely liquid only at 1577° C Conversely, on cooling, forsterite crystals separate at this latter temperature and continue to separate until the temperature of incongruent melting (1557° C) is reached At this constant temperature they react completely with the liquid of composition ($MgSiO_3$ 97 5 per cent, SiO_2 2 5 per cent) to form $MgSiO_3$ At perfect equilibrium, the crystals of Mg_2SiO_4 and the liquid are exhausted simultaneously, and only $MgSiO_3$ crystals remain Thus we see that the liquid of composition, $MgSiO_3$, with perfect equilibrium, follows an involved path of crystallization, but yields only crystals of $MgSiO_3$ We note, however, that forsterite (Mg_2SiO_4) crystallized first, and at a lower temperature reacted with liquid to yield clinoenstatite ($MgSiO_3$). Such a pair of minerals is called a reaction pair

When cooling is too rapid, complete reaction between crystals and liquid at the reaction point fails to take place quantitatively, the course of crystallization is changed, and we may have crystals of forsterite, clinoenstatite and silica in the final product. In this reaction process we note the nature of the origin of reaction rims of pyroxene (clinoenstatite) around grains of olivine (forsterite) in rocks

More Complex Systems

In the foregoing discussions only three of the simpler but important types of binary systems have been considered No reference has been made to partial or limited solid solutions, to components with several different crystalline modifications and to many others Although many ternary, or three-component, systems have been thoroughly investigated, no quaternary, or four-component, system of silicates has as yet been completely studied.

We shall include here a diagram (Fig 9) of the ternary system, $CaO—FeO—SiO_2$, without complete explanatory details An equilateral triangle is used to express chemical composition in terms of three components If we expressed temperature vertically from this triangular base, we should have a triangular prism. To retain a plane figure, we indicate these temperatures by contours of temperature called isotherms A diagram of the system, $CaO—FeO—SiO_2$, without isotherms, is given here to show how fields of stability of minerals are delineated Additional diagrams, showing isotherms, paths of crystallization and three-phase boundaries, are necessary for a more complete presentation of the laboratory data

To represent a quaternary system, we use a tetrahedron whose faces are equilateral triangles For convenience, we often show, as a plane figure, the tetrahedron with its faces laid down on the plane of its base Such a diagram is given

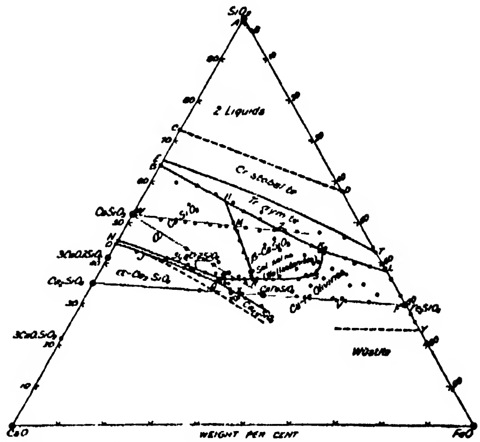


FIG 9 THE SYSTEM, $CaO—FeO—SiO_2$, WITHOUT ISOTHERMS, SHOWING FIELDS OF STABILITY OF MINERALS (BOWEN, SCHAIRER, AND POSNJAK)

in Fig 10, which represents in skeleton form three different quaternary systems that are now being studied to ascertain the nature of residual liquids from fractional crystallization in compositions which approach those of certain rock magmas.

Complex Mineral Groups

Earlier, we asked many questions about the nature and variations of the individual minerals found in igneous rocks.

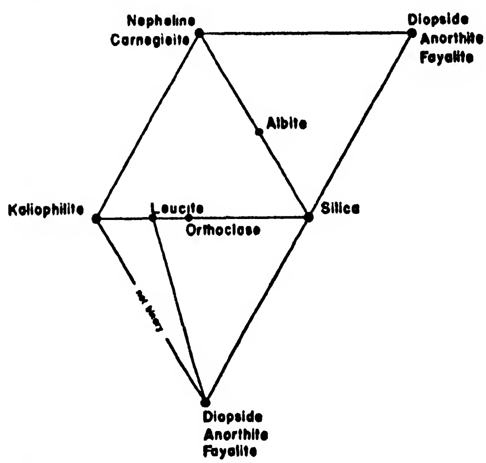


FIG 10 QUATERNARY DIAGRAMS SHOWING INTERRELATIONS OF SYSTEMS INVOLVING BOTH EARLY- AND LATE CRYSTALLIZING MINERALS OF IGNEOUS ROCKS

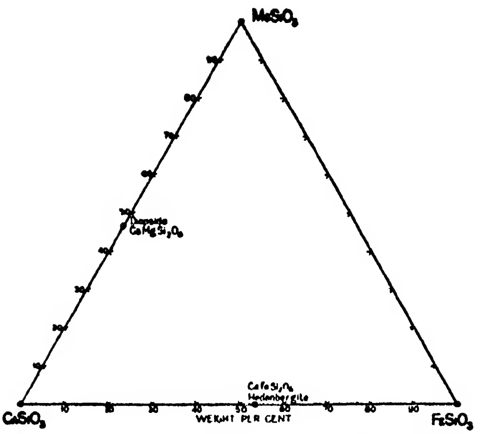


FIG. 11 THE COMPOSITION TRIANGLE, $CaSiO_3$—$MgSiO_3$—$FeSiO_3$ (NOT TERNARY), SHOWING THE MOST IMPORTANT MOLECULES OF THE ROCK-FORMING PYROXENES

Here, we shall select one of the most important groups of rock-forming minerals, the pyroxene group, in which N L. Bowen and I have had a particular interest The pyroxenes present exceptional complexity both of crystalline modifications and of chemical composition They are a series of polycomponent solid solutions, some of the molecules of which are completely miscible and others only partly so The important mineral molecules which enter into the composition of the rock-forming pyroxenes are given in Table III The three most important molecules are the metasilicate molecules

TABLE III

MOLECULES OF THE ROCK FORMING PYROXENES

$CaSiO_3$	Wollastonite, pseudowollastonite
$MgSiO_3$	Enstatite, clinoenstatite
$CaSiO_3$ $MgSiO_3$	Diopside
$FeSiO_3$	Ferrosilite, clinoferrosilite
$CaSiO_3$ $FeSiO_3$	Hedenbergite
$MnSiO_3$	Rhodonite, bustamite
$CaSiO_3$ $MnSiO_3$	Johannsenite
Molecules containing	
Al_2O_3	Augites
Fe_2O_3	Augites and babingtonite
TiO_2	Titaniferous augites
Na_2O Al_2O_3 $4SiO_2$	Jadeite
Na_2O $Fe_2O_3 \cdot 4SiO_2$	Acmite, aegirite

$CaSiO_3$, $MgSiO_3$ and $FeSiO_3$ The compositions of these are indicated in Fig 11. Laboratory data for the sides of the triangle are already complete. The relations between diopside and $MgSiO_3$ are given in the ternary system, diopside—forsterite—silica $CaSiO_3$ and diopside form a binary system in which there is a limited amount of the diopside molecule in solid solution in the low-temperature form of $CaSiO_3$ (wollastonite). Data for $CaSiO_3$—$FeSiO_3$ and $MgSiO_3$—$FeSiO_3$ have been published in the ternary systems, CaO—FeO—SiO_2, and MgO—FeO—SiO_2, respectively The incongruent nature of the melting of acmite has been determined and complete data are given in the system, Na_2SiO_3—Fe_2O_3—SiO_2. Studies are now in progress, or are planned for further determination of the exact composition-temperature-stability relations in this important rock-forming mineral group

CONCLUDING REMARKS

In this place, we could hope to indicate only the general character of the processes operating in nature to produce the great diversity of igneous rocks. From the foregoing presentation, we may realize that, although the broader problem of the chemistry of igneous rocks concerns only ten rock-forming chemical substances, it is, indeed, an involved but very fascinating one. We have seen that orderly physical and chemical principles govern the processes, and that it is possible, by dividing the problem into many interrelated simpler problems, to study the actual temperatures and processes of rock formation in the laboratory, and to use certain minerals as geological thermometers Each mineral system that is studied yields information concerning certain processes of rock formation, but usually raises many new problems that await further experiments for their solution Science continually seeks new truths or a better understanding of the old ones.

ARE WE ALONE IN THE UNIVERSE?

By Dr. R. S. UNDERWOOD

PROFESSOR OF MATHEMATICS, TEXAS TECHNOLOGICAL COLLEGE

WHEN most people looked upon our earth as a unique flat surface stretching all the way out to the base of the sky-bowl and resting on bed-rock, which reached, presumably, all the way down, man's position was a delightfully happy one. The limited size and well-stocked condition of creation satisfied his gregarious instinct and gave him a comforting sense of all-pervading companionship, while his obvious preeminence among created things left absolutely nothing for his vanity to crave. Those, indeed, must have been the days!

But always in human affairs there has to be some prying intellectual to spoil the perfect bliss of ignorance Some one, sooner or later, was bound to knock out the foundation which supported earth and sky, leaving only a round ball suspended lonesomely in space, and a rolled-away curtain where once had been the friendly gate of heaven. Bleak emptiness was beyond, except for scattered flaming beacons like the sun, a pinch, here and there, of debris, and a few insignificant earth-cousins all but lost in the void. No wonder that thoughtful persons scanned those tiny balls with wistful eyes, looking for signs of activity which would remove that new sense of cosmic loneliness and give mankind companionship, at least, in place of his lost focal position in the scheme of things No wonder that enlightened religious leaders longed for scientific assurance that the great universe was not pricked in one spot only by a tiny stir called life—a stir so infinitesimal in the stupendous setting of blind mass and force that it could be nothing more than a chemical accident. Even yet life might take on meaning and dignity if only it could match the boundlessness of space with an all-pervading quality of its own

But help came only slowly from the scientists. There was a time, not so long ago, when top-rank astronomers apparently considered it beneath their dignity to discuss the question of life on other worlds The gradual turn of the tide is probably due chiefly to the growing conviction that this is a genuine research problem and not just a subject for unverifiable guesses And this particular development is certainly of much more importance than the latest conclusion about the atmosphere of Mars in respect to its fitness for human beings. For it means that the possibility is at last recognized that earth-bound creatures may be able eventually to know with certainty that there is or is not life on Mars, that there is or is not life on Venus, and even, perhaps, that life exists or does not exist on the remote satellites of other suns and other galaxies It means, further, that scientists investigating any of a thousand problems in astronomy, physics, chemistry and other fields will keep always on the watch for data bearing on a very live question, realizing more and more how numerous and diverse are the odd bits of knowledge or theory which may prove now or later to be significant

Already the accumulated direct and indirect evidence would require many books for a reasonably complete discussion An article such as this, then, can do no more than point out a few of the main considerations and lines of evidence.

Logically, perhaps, we should first ask what is meant by "life" Any attempt at a definition, however, gets us into philosophical and biological niceties which only obscure the point at issue, since most of

us believe that we could recognize the phenomenon in almost any of its probable forms After all, we find upon introspection that we are emotionally concerned not so much with other-world life as with consciousness, and particularly with the higher form of the latter called "intelligence" But since on earth life-quickened matter and the cruder organisms merely set the stage for the climactic appearance of mind and thought, there will be for many people a keen interest in the search for mere extra-terrestrial life in any form whatever

One other matter of a general nature remains to be discussed before we consider specific sites of possible life It has been remarked that earth-life derives from two chief facts first, the instability of carbon compounds within the temperature range found on our planet; and second, the presence of water as a medium of solution These dual prerequisites have allowed a tremendous variety and range of living forms, from bacteria to whales in size, from equator to pole and from ocean depth to mountain top in place, and from seconds to centuries in individual life spans And yet they have at the same time indicated a possible limit in the conditions which our kind of life can endure without the artificial aids of intelligence · a forbidding zone of perpetual cold like that approached in the Antarctic wastes, of drouth such as Death Valley holds, and of heat like that in the geysers of Yellowstone Park Beyond these limits, it is true, something totally different might emerge in the mysterious ways of creation—such forms, for instance, as could live in a world of blazing heat by virtue of silicon life cells fed by molten iron bloodstreams But perhaps the greatest single lesson of astronomy is that of the essential unity of observed creation One set of chemical elements apparently suffices for the earth, the sun and all the known galaxies of space, and one great law of gravitation holds every celestial body in its place. It seems reasonable, then, to look first of all for *our* kind of life on the other planets, and to assert for the purposes of clarity that such strange creatures as may be stirring in the places beyond the pale of earth-living conditions are not examples of what we are pleased to define as life. This gives us a dogmatic basis upon which to exclude the overwhelming bulk of matter in the universe, including our own sun and all others, and probably, though not certainly, nebulous and meteoric material, planets too near to or too far from their primary suns, and planets too small to hold an atmosphere.

What remains? Well, in our own solar system, in addition to the surely inhabited earth, there are several prospects worth examining in detail, while outside this system the sky is literally the limit Suppose we consider first of all our two immediate planetary neighbors

Coming often within fifty million miles of the earth, and occasionally venturing within astronomical speaking distance only thirty-five million miles from collision, the planet Mars naturally rates a good deal of attention from mere neighborly curiosity on our part But when, on the seasons of near approach, we peek out through our telescopic windows and find that the shades are up invitingly; that a well-marked face, peering at us in the revealing sunshine, gives more than one hint of strange goings on, and that we have before us almost, but not quite, enough detail to settle some vexing questions immediately, is it any wonder that our scientific interest is spurred to the point of extra-special investigation, and that one man at least has made this puzzle a life-study? Here, unquestionably, is one of the most promising sites of life in the none-too-select astronomical neighborhood of the belligerent earth-beings.

Most of the significant features of Mars have been described so often in popular literature that they will be pointed out

only briefly in this broader survey. First we should note the remarkable similarity to the earth in the two astronomical features of a twenty-four-and-a-half hour day and a season-making axial tilt which is practically identical with that of our planet The important distinctive features are the planet's smaller size and consequent lighter atmosphere, and its greater distance from the sun, by about one half This last feature means, of course, that less light, heat and energy are received per unit of surface Then there are the white polar caps, suggesting snow, fog or hoar frost, which appear rather suddenly in the Martian winter, dwindle away at ragged edges in the spring, and sometimes disappear entirely in the summer There are the seasonal darkening stages of the permanent markings which suggest the growth and ripening of vegetation, and which are indeed hard to explain under any other hypothesis And finally there are the controversial canals, seen as geometrical lines by some and as ill-defined streaks by others, but existing at least in the form of broad channels which have appeared in photographs The crux of the argument about the canals lies in the fact that the patient observer can undoubtedly view more details through the telescope, in the fleeting moments of good seeing, than can be photographed by a process which averages good and bad conditions Eventually, perhaps, a lucky photographic shot aided by an improved technique allowing shorter exposures may yield a clear-cut picture which will settle the issue But in the meantime it seems fair to state that the majority opinion of astronomers has tended more and more to the conclusion that the odds are in favor of some kind of plant life on Mars But on earth animals eat plants, and plants live on carbon dioxide existing primordially in the free state or exhaled by animals Perhaps there are parallel conditions on Mars It is true that no trace of carbon dioxide has as yet been found in the Martian atmosphere On the other hand, the spectroscope appears to reveal a trace of oxygen, and much more seems to have been tied up in the oxidation of the red Martian surface, like our Painted Desert sands. Since in the theory of planetary gases oxygen is believed to appear in the free form only as it is liberated by plants, this trace of the element is another link in the chain of evidence which makes the still incomplete case for the thesis of life on Mars

Next on the list of probable life-harborers is the planet Venus, our celestial neighbor on the sunward side Less than twenty-five million miles from the earth when closest, and considerably larger than Mars in addition, it would be the obvious candidate for the most intensive study if it did not, logically enough but none the less annoyingly, always turn its dark side toward us on these near approaches A second disconcerting attribute is a heavy blanketing atmosphere which so effectively hides the surface that no earth-man knows how often it turns around And that apparently minor point has a highly important bearing on the question of its habitability For if one side always faces the body it circles, as is apparently the case with Mercury and all minor satellites, that face must be unbearably hot, the other side must be dark and frigid, and the borders must be blasted by endless hurricanes As a matter of fact, a rotation period equal to about thirty of our days is indicated by some meager lines of evidence Even in the extreme case of a day equal to the year, the chances for life on Venus would not be hopeless, but in view of an uncertainty about a vital matter which is probably only temporary, it seems best not to allow this prospect any more of our crowded space

Mercury, nearest known planet to the sun, has little or no atmosphere, and also has the almost fatal habit of keeping one

face toward the celestial furnace. Jupiter and Saturn, huge and distant planets blanketed by heavy atmospheres which seem to be composed largely of ammonia and methane gas, are likewise poor prospects as life-bearers, while their satellites and the outer planets are even less promising One would certainly be rash to deny dogmatically that life exists on any or all of these places; but it seems safe to state that the *present* odds are against the existence of our particular kind of life.

What about the moon? A generation ago a schoolboy would have recited the conditions thus, with glibness and finality: "The moon is a pock-marked satellite of the earth, deceased long ago if she ever lived, and now totally without water, atmosphere or life"

Has the verdict changed? Only in the not insignificant respect that the proper phrase is now "no appreciable atmosphere" Certainly it would be highly surprising if the moon were proved to be totally airless, since the nearby earth receives daily millions of meteorites containing each its quota of gas. There is no inconsistency in the probable consequence of this fact and the very clear proofs that our satellite is practically without air. The question is merely a matter of degree—of how much contraband gas the moon might smuggle past our delicate detecting instruments. In the May, 1938, issue of *Popular Astronomy* appears this statement "As far as actual observational evidence goes, it appears that values of lambda less than two times ten to the minus four have not been excluded," which means in plain English that the surface of the moon could, for all we know to the contrary, have an atmosphere about five thousand times more rare than our sea-level air This conclusion assumes more importance in connection with repeated observations in one lunar crater, and, to a lesser degree, in others, of daily changes ascribed *possibly* to some low form of moss-like growth.

A related observation will give some hint of how widely ramifying are the clues in this great investigation. It is to the effect that there are surprisingly few indications on the moon of current changes due to meteoric bombardment, and that no light-flares from impacting meteors have ever been observed on the darkened surface at the new or quarter phase. Coupling this development, which is theoretically improbable on the assumption of a totally airless moon, with the observed fact that most earth-encountering meteors are consumed by friction at a height at which our own planet's atmosphere is extremely thin, we arrive at the startling conclusion that maybe after all the moon gets a little atmospheric protection from pelting rocks. At least we see that the question of barrenness or life is not an entirely closed subject, even in the case of this nearby rocky outpost.

And now finally, when we come to the endless possibilities for life outside the solar system, it may be thought that here at least is a field in which we can never hope to bring investigation to the aid of our hopeful surmises. But again this is not the case For one line of attack appears immediately. How likely and how frequent, among the uncounted Milky Ways of space, is the kind of rare accident or common celestial occurrence which called the earth and its sister planets into being? This, of course, depends upon our explanation of the origin of the solar system And, fortunately, so mathematically precise must be the final theory in order to account for things as we find them, that it can scarcely be false when once it is entirely satisfactory Already one feature of the final plan has emerged clearly and almost unmistakably to give us encouragement—that of a plane determined by a point and a line, the point being the sun and the line the path of a passing star.

But the comparative frequency or rareness of a habitable planet like our earth

depends also upon many other factors which are in the pathway of present investigations. It depends upon the star density, past and present, of our galaxy and the millions of others known; upon the number and distribution of space derelicts—dead suns which might pass living ones and leave planetary systems in their wake, upon the nature of a star's life history, with the working clues of variable, binary and exploding or "new" stars. It depends upon the currently debated existence of living spores within the messengers of space—the free-coursing meteorites—which may even now be carrying the seeds of life from dying worlds to new and fertile fields. It depends, in fact, upon the whole astronomical picture now unfolding before us, and, less directly but no less certainly, upon the entire interlocking field of science.

The question, you will note, centers upon the probable number of planetary systems per million or billion of suns rather than upon the likelihood that our particular system has no near-counterpart in space. Most astronomers to-day are inclined to think that a planetary family is a comparatively rare phenomenon in space, but probably no one would make the statement stronger than that Certainly the whole burden of proof would rest upon the rash theorist who would make our solar system unique in the universe. To get an idea of the probabilities involved one has only to recall that by a very conservative estimate there are, in the galaxies within range of present telescopes, not less than one hundred million billion suns. Enough suns so that, if they were reduced individually to the size of buckshot, they would fill a line of trucks strung end to end from Boston to San Francisco and folding back on itself about two hundred times. One would be a trifle brash to claim special status for the buckshot he loves best in this caravan! And when one of the chief laws we see in operation about us is that of repetition, the chance that we are not alone in the universe seems to border as close upon certainty as anything we know that has not been proved

Thus the stage is set, and the little planet Mars is seen to have been given undue significance It seems to have life, but if this is a mistake, it doesn't much matter after all The important thing, astronomically speaking, is that here is a sun with at least one inhabited satellite—our earth If Mars is as dead as the proverbial doornail, we can still look outward with confidence that blind chemical forces have not cast us up as living accidents on the huge dead banks of eternity. Somewhere in space are many, many fellow-travelers on the brief but hopeful trek of life.

ANIMAL EXPERIMENTATION

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In beginning my discussion of animal experimentation, I wish to give initial emphasis to the second word of our theme, not the first For experimentation, being primarily a method of discovery, has not only been making extraordinary contributions to our knowledge and culture at a constantly increasing rate, but possesses certain properties of great interest quite apart from the materials the experimenter may select as most suitable for his problem Experimentation with animals has the same general objective as experimentation with plants and with materials supplied by inorganic nature The materials are of secondary importance. The problem is the focus of interest

If there is one thing more than another that characterizes us all, it is, I suggest, our common immersion in a sea of problems Some of them spring up out of immediately practical individual needs—for food and clothing and protection from the elements, from disease and from each other Some of them belong especially to family life, awakening questions on reproduction and sex and development and heredity and the educational process Some pertain directly to the larger life of the community and nation, to crime and corporate behavior and the exchange of the stupidities of war for the enlightenments of peace And others carry us willingly to the frontiers of knowledge with only understanding and appreciation as our goal

Whatever our problems, and however near or far, we solve them adequately only with adequate techniques In early childhood, these were miraculously simple. It was enough to lay our questions on our mother's knee or some other altar similarly consecrated by our gifts of faith An authoritative word was our sufficient solution, as in the days before the dawn of science, when supplication usurped investigation's place

As a matter of history, science did indeed show itself clearly above the naive intellectual horizon characteristic of childhood only when processes began seriously to awaken the same sort of compelling interest as the results to which they led For the immediate and familiar needs of every day, man had been accustomed from time immemorial to use his common sense Confronted with less familiar issues, remote from his pressing creature wants and transcending his rule-of-thumb techniques, he had long been content to comfort his ignorance with supernaturalism The time came, however, when reflective minds perceived that the gods they had created were no less fallible than themselves There followed the conviction that intellectual security was to be found for practical men in the causal mechanisms of events rather than in the events themselves

Though this conviction was expressed in highly speculative forms, it was basic to scientific progress Six centuries before Christ the imaginations of a Thales and an Anaximander sketched the broad outlines of a universe that was for the first time self-contained and mechanically conceived, capable of investigation from within, independent of interference from without. Henceforth, scientific knowledge was to accumulate in direct proportion to the development of adequate techniques of observation.

Foremost among these is what we commonly call the scientific method. Typically, it begins with a *question,* which

receives a tentative answer, the *hypothesis,* that is then put to a test in the form of a critical investigation of the problem thus defined It is, *par excellence,* a method of discovery, giving to observation both motive and direction But discovery may lag Outstanding among accelerating devices is the experiment, which attains its full importance in the investigation of mechanisms and processes. For the present discussion it may be characterized briefly as observation under conditions that are chosen, arranged and controlled by the observer himself Experimentation is thus a serious and aggressive intellectual procedure suggesting neither the passive receptiveness of a photographic film nor the wanton curiosity of one who kicks a dog to see what it will do

By way of illustration, let me recall the story of an experiment with animals that was not only a model of simplicity and method but historically significant as well It began with Homer In the nineteenth chapter of the Iliad, he put into the mouth of Achilles, mourning over the body of Patroclus, a fear lest flies enter the latter's wounds and breed worms therein Five centuries later, this common fact of Homer's day had apparently escaped the attention of Aristotle, who accounted for maggots in decaying flesh by a spontaneous, or, as Harvey used to say, equivocal generation Backed by Aristotle's enormous prestige, this view persisted unquestioned by the bookish few through the dark vicissitudes of the next two thousand years before being put to an objective test

The seventeenth century had arrived, with the microscope and the barometer and the thermometer and the air pump and other devices that promoted quantitative observation and stimulated accurate inquiry Galileo had been born and driven into retirement by ecclesiastical authority Not, however, before he had made his classical experiments on falling bodies. A product of his influence, the *Accademia del cimento* had been organized, dedicated to the promotion of experimentation Into this new company of explorers, the Tuscan physician Francesco Redi was admitted. He knew the Iliad and the biological books of Aristotle He knew also the practice of the butchers of his day, who believed that their wares could be kept free of worms by excluding flies with coverings of cloth. "But," he said in a noteworthy sentence from his "Experiments on the Generation of Insects" (1668), "belief would be vain without the confirmation of experiment, hence in the middle of July I put a snake, some fish, some eels of the Arno, and a slice of milk-fed veal in four large wide-mouthed flasks; having well closed and sealed them, I then filled the same number of flasks in the same way, leaving them open " In so doing, Redi provided what we now recognize as an essential in every well-conducted experiment—its *control* He goes on "It was not long before the meat and the fish in these second vessels became wormy and flies were seen entering and leaving at will, but in the closed flasks I did not see a worm, though many days had passed since the dead flesh had been put in them " Subsequently, Redi improved his technique by using a cover of Naples veiling that permitted air to enter but excluded flies as before In this case he had set up an experiment in which the covered jar differed from its control in one essential only It was an *experimentum crucis,* the technical ideal of every experimenter The results were as before So it appeared that the butchers, following the ancient Bard, had been right, and the philosopher, leaping with closed eyes to a conclusion, wrong

But the possibility of spontaneous generation had not been eliminated, especially of those minute organisms first revealed by the lenses of Redi's contemporary Leeuwenhoek New experi-

ments were forced by criticism to new refinements of technique that in turn provoked new subtleties of criticism. By mid-nineteenth century they had come to the ears of the young chemist Pasteur, whose later extraordinarily beneficent researches on and for animals and man need no further reference here. His experiments as a bacteriologist extended to the limits of microscopic vision the conclusions reached by Redi for maggots.

But further exploration opened up a world of still more minute existences. Ultramicroscopic bacteriophages and viruses, being invisible, were recognized by what they did. Many of them have now been measured with quite reasonable accuracy by methods not requiring them to be seen It is still recent news that the virus concerned with the propagation of the tobacco mosaic disease has been isolated in crystalline form, a prelude to the investigation of its composition and chemical structure Such discoveries have added further impetus to the exploration of the borderland between the living and non-living world already being approached from several other directions Far more immediate interest, however, is being shown in the mechanisms underlying vital activities, than in the possible event of spontaneous generation itself. Let us leave Redi's problem, then, at this point, to consider a modern experiment differing from his in motive and material, involving a very simple operative procedure, and selected especially for its striking simplicity in general.

Recall if you will the microscopic "bell-animalcule" *Vorticella,* its sub-conical body set like a narrow wine glass on an excessively slender stem, and its free edge bordered by hairlike cilia whose rapid beating creates vortices in the water drop that is its universe. Always a fascinating object to the microscopist, it is especially (I had almost said doubly) so when in process of division.

This was as a youngster in my laboratory had discovered it, one lunch hour, when I found him sharing his attention between sandwich and microscope. He had made an admirable series of line drawings in which one could almost see the fission plane pass gradually from the ciliated mouth of the "bell" toward the stalk. There were now two sub-conical bodies not yet fully separated and superficially very much alike On one of them, however, there was a second set of cilia, near the apex of the bell, which were entirely absent in the other. Furthermore, the latter was now in full possession of the stalk The fission plane had passed a little to one side of it, leaving the individual with the new ring of cilia hanging to the other by a tenuous protoplasmic strand Here, then, was the situation: the individual with the new ring of cilia lacked a stalk, while the individual with the stalk lacked the new cilia.

What was the explanation of this difference? It looked as though the stalk somehow prevented the appearance of the cilia that became visible only in its absence Adopting this as a preliminary guess or hypothesis—how was it to be tested? One obvious method was to amputate the stalk of a normal individual This led, however, to certain technical delays Needles must be sharpened to a fine cutting edge; and the operator must develop skill sufficient to use them in a water drop under a reversing microscope that made a needle actually entering from the right appear to be entering from the left He must also be able to put the cutting edge down precisely where the stalk joins the body, notwithstanding complications introduced by the usually spasmodic contractions of the stalk itself when touched.

All these obstacles were finally surmounted The delicate operation was performed at last with complete success, and the vorticella swam directly away from its stalk, bell mouth foremost. It was on that aspect of the body that it

came to rest after several minutes, the apex of the bell from which the stalk had been cut pointing most fortunately right up into the microscope. Fifteen more minutes passed Then, unmistakably, the beginnings of the expected cilia were suggested as a ring of barely visible dots These became as we watched them delicate hairlike processes, that as they lengthened began to wave slowly and rather uncertainly, then faster and faster until, full grown and beating in a unified rhythm with great rapidity, they bore the stalkless body up into the drop, apical (*i e*, stalk) end now in advance

It was clear that cilia could develop in the absence of the stalk. But would they persist if the stalk should reappear? The answer to this question came when the swimming body finally touched and stuck to the substratum just where the stalk had been cut off. For at that point a new stalk began to grow out under our eyes As it lengthened, carrying the bell up with it, the cilia completely disappeared by absorption

The operative experiment in miniature had now reached its immediate objective, not, however, without stimulating other questions concerning the *mechanism* controlling this extraordinary alternation of specific structures These brought it at once into the company of a mass of experimental data on interdependence of parts and dynamic equilibria in living systems that had already accumulated from many sources, especially from the simple plastic organisms of which we have been contemplating an extreme case

There is not time to go into this vastly interesting field of experimentation It can only be said that these studies have now progressed in some cases to such a point that chemical substances are being recognized as important factors in the processes of development and differentiation Though we still know little more of the cilia-stalk relation in *Vorticella* than the fact itself; and though it still remains an absorbing mystery how the cut end of a flatworm becomes reorganized into a new head, it is probable that such mechanisms involve chemical factors just as they unquestionably do in certain other cases The so-called organizer of Spemann, for instance, is but one of a group of substances whose presence in the amphibian embryo at the right times and places has been shown to provide the necessary conditions for a normal development What Claude Bernard first called internal secretions, now commonly associated with the activities of the ductless glands of the higher animals, including man, are actually produced to some extent by every active cell in the body Since the discovery of *secretin,* we have had an intelligible mechanical explanation for the remarkable way in which the pancreas pours its characteristic digestive juices into the intestine just as food ready for digestion is passing through Even the characteristic activation of muscles by nerves has recently been shown to be produced by such well-known substances as adrenalin and acetylcholine secreted at their motor terminals A small army of investigators is showing, similarly, that characteristic sex phenomena involving both form and function in men and women are dependent on internal secretions whose composition in some cases is now well known Though it is not within the limitations of this paper to describe them more specifically at this time, it is desirable to suggest that the chemical correlations that are being successfully studied in such highly complex organisms as man exist also in some appropriate form in every organism however minute and simple and in every cell

Other aspects of the general problem are being outlined by students of genetics who are attempting to define more clearly the conditions under which the genes (constituting the physical basis of

heredity) are characteristically active This is done in the first place by transferring given tissues—such, for instance, as a patch of skin from a fowl or the rudiment of an eye from a *Drosophila* larva—from their normal setting to animals of similar type but different genetic constitution, where they must develop under conditions not entirely similar to those from which they were removed Even the behavior of single genes has been observed in connection with eye color in *Drosophila*, a subtlety of approach to the traditional issue between heredity and environment that has already yielded positive results and is being pursued, as all fundamental physiological problems must be ultimately, with the cooperation of chemists Since genes are known to react with their near neighbors occupying places on the same chromosome, such studies promise to throw much needed light on some of the most fundamental mechanisms of protoplasmic organization

From such general considerations, I will now ask you to turn with me to an investigation of a very special type that came under my observation a few weeks ago in a New York hospital Its *motive* was initially practical, the *method* was quantitative, calling for a large number of carefully controlled measurements of physiological processes by means of elaborate and finely adjusted apparatus over a long period of time, the *material* consisted of a series of human infants prematurely born

You are aware that the life expectancy at birth in this country has increased to its present value of about sixty years largely through a corresponding decrease in infant mortality In 1935, the infant death rate within one year of birth was less than half what it was in 1915, thus reflecting the progress of knowledge and improved infant care During the same two decades, however, the death rate within one month of birth had doubled; and the record showed that approximately sixty-five per cent. of the fatal cases had been born prematurely. Such figures revealed a public problem of very large dimensions They also suggested the strategy of investigations now under way, in which the requirements of *premature* infants occupy places of peculiar importance

In the hospital to which I refer, a suite of rooms has been isolated and furnished for studies of infant metabolism. In the midst of its admirable equipment—the fruit of many years of experience and criticism—one could not help thinking of the great pioneer Lavoisier, whose quantitative studies with balance and calorimeter led him to a true conception of the rôle of oxygen in the rusting of metals, the burning of inflammable substances and its relation to the subtler combustions continually going on within the body itself His measurements of the respiratory exchange of gases in man at work and rest were the first of the kind and laid the foundation for modern respiration calorimetry, a familiar clinical application of which for the determination of the basal metabolic rate is now a commonplace of medical practice

In the present case, the calorimeter was a small oblong metal box in which an infant under observation could be placed, comfortably clothed and resting on a little mattress so shaped that all excretions might be conveniently collected *in toto* for subsequent investigation There was a glass window in the air-tight cover An ample measured supply of air, after passing through a series of bottles that removed all its moisture and carbon dioxide, entered at a constant rate by a single opening Within the chamber, which was kept at a constant temperature, this air picked up moisture again from the lungs and skin of the infant, the desired humidity being maintained by regulating its rate of flow On leaving the chamber, it passed through an-

other set of drying bottles, and in addition, small samples of air were withdrawn by a very ingenious automatic device at regular intervals and pooled for quantitative analysis

Without going farther into details, I hope this sketch of the apparatus has made clear its design, namely, the most accurate possible measurements, under the most carefully controlled conditions, of everything taken from the air by the infant during the period of observation and everything eliminated, whether solid, liquid or gaseous From such measurements of a long series of infants, significant typical changes in their metabolism have been correlated with changes in their age And progress has been made in two obvious directions, first, in a more effective control over the hazards to which premature infants are subjected; second, in fuller understanding of the physiological mechanisms fundamental to the development of man and of organisms in general This intimate relation between the results that can be used at once and those for which no occasion has yet been recognized deserves more consideration than we can give it now Instead, you will be glad to hear that the babies cooperating in this experiment in human biology have returned to their mothers invariably benefitted physically —and by all the usual signs emotionally also—by these brief episodes of service to compatriots not yet born Though they slept unconscious of it all, their mothers knew what they were doing, were always willing and often very proud As a result of many investigations along similar lines, by many observers, premature babies no longer die for lack of air-conditioned nurseries in well-equipped hospitals of the present day

Another experiment on human material came to my attention that same evening when we saw "Yellow Jack," a screen version of the famous expedition of Walter Reed and his colleagues to Cuba that established on a sound experimental foundation the agency of a mosquito (*Stegomyia*) in the dissemination of yellow fever and the first great step toward its control I shall not recount this now familiar and very honorable story. What you have seen or may see on the screen is entirely authentic as to all essential details For the experiments, an organism was needed that was itself susceptible to the fever Man alone at that time was known to meet that requirement So five enlisted men volunteered for this hazardous service, as men have always volunteered when the hazard and the need were great Would you have had them do otherwise? To-day, we know that mice are adequate and far more convenient material for experiments still in progress World-wide exploration for the sources of the disease have made it unfortunately clear that the magnificent intention of the Rockefeller Foundation to destroy it completely can not be fulfilled But man can now be immunized against it And the method now in use, by which several hundreds of thousands of individuals have been protected, was developed, all Californians will be interested in recalling, by a former secretary of their State Board of Health, now director of the International Health Division of the Rockefeller Foundation, Dr Wilbur A Sawyer

Though not one of the five volunteers lost his life in the original experiment in Cuba, you are aware that one of the staff of investigators, Lazear, died; and that three other distinguished investigators have since been sacrificed Dr Sawyer recovered from an infection obtained in the course of his investigations Courage of this sort has been a commonplace among physicians ever since Thucydides, describing the plague of Athens, testified as an eye witness that "physicians died themselves most thickly, as they visited the sick most often " It took courage of the same order for Reed to issue his call

for volunteers Grateful relief is expressed in these words of his written to his wife when the result of the experiment was clear

> . . It has been permitted to me and my assistants to lift the impenetrable veil that has surrounded the causation of this most wonderful, dreadful pest of humanity and to put it on a rational and scientific basis . . The prayer that has been mine for 20 years, that I might be permitted to do something to alleviate human suffering, has been granted.

During my first days in a physiological laboratory, I made the acquaintance of a dog who had long been a cheerful source of gastric juice delivered as needed through a gastric fistula established by operation five years before He was amiable, had a habit of chasing his tail until he became too stout for that exercise, and held an honorable place in our regard as a contributing member of the scientific staff

Twenty-five years later, a younger relative met a group of dogs at Johns Hopkins School of Medicine that had been trained to assist in an investigation then under way Each of them, as his turn came, would jump up on the operating table, lie down—wagging his tail perhaps—and without being restrained in the slightest, would permit the operator to plunge a hollow needle through the chest wall into the heart so as to withdraw blood directly from that organ. This was a routine procedure, many times repeated The dogs gave the same evidence of pride in performance as dogs do that retrieve game or entertain their master's friends with tricks Similarly, you will recall, dogs helped Pavlov and his co-workers through many routine experiments in their studies of the physiology of the learning process that brought new objective and quantitative methods of wide applicability to psychology and a new term—the conditioned reflex—into our language

Such contributions to the advancement of knowledge give experimental animals a place of peculiar importance in human affairs The death that frequently overtakes them does not lessen it On the contrary, death acquires from this permanent service a certain dignity that mere extermination as a community problem in the public lethal chamber can not ever confer

UNDERSTANDING HUMAN GESTURES

By MAURICE H. KROUT
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GESTURES as a species of human behavior have been sadly neglected The greatest of psychologists, Wundt and Freud, have not exactly neglected them, but have done little more than mention them Most psychologists completely disregard them Until recently no one tried to study them experimentally, and even now there are more problems connected with them than any psychologist could hope to solve in a lifetime

Every layman knows that people gesture, since gestures are commonly employed in social intercourse Every one is familiar with the fact that some individuals perform nervous movements or possess so-called mannerisms There are, however, gestures hardly noticeable to the untrained eye, for which no appropriate name was known until recently, and which differ from the rest How then can we distinguish the various types of gestures from each other? When and why does each type occur? If their meaning is clear when they are used in communication, what do they mean when not so used?

Boards of trade use gestures in buying and selling grain for future delivery With the fingers held vertically brokers indicate quantity Each finger is used to represent five thousand bushels, and as many as twenty-five thousand bushels may be represented by four fingers and the thumb Movement toward the trader means buying; movement away, selling For prices there is another code One finger extended means one eighth of a cent, and so on to five eighths When the four fingers are extended, but pressed close together, three quarters is indicated The clenched hand with the thumb alone extended means seven eighths of a cent, while the thumb between the index and the middle finger is the signal for a split quotation

Scouts have a language of their own Throwing both hands up means "Nothing to fear!" Holding an open hand aloft, and moving the arm from right to left and from left to right, a few times, means to scouts, "Attention!" Thrusting the arm forward means "Stop!" with both policemen and military men Swinging the hand from the shoulder across the body to the other side, in a horizontal direction, means, in military language, "Go this way!"

Gestural expression was common among North American Indians They had thousands of signs to convey meaning without sound, but other peoples have also used gestures for this purpose The natives of Timbuctoo place two fingers astride a finger of the other hand to indicate riding Similarly, when they press a heavy head against an open hand, they mean "Go to sleep" Closing the fist with the thumb between the index and middle fingers indicates derision among certain Europeans Turning the back and lifting the skirt is a sign of disrespect among the French and others Throwing the head back and making a chucking noise with the tongue signifies negation among Turks Massaging the abdomen to show satisfaction was common among Indians, and is still imitated by our youngsters The Ainus of Japan lightly tap the nose or the mouth to express surprise, while the Negro Bantus of Africa move their hands before the mouth, when surprised, and Australian aborigines protrude their lips as if to whistle

Ceremonials in various groups have relied on gesture for communication of meaning and thought Indeed, this type of communication had served the purpose of social control before government by law or canon began to serve that purpose. For instance, the ceremonial involving the expression of affection requires, with us, embracing and kissing on the mouth or cheek; but when our civilization was still in its beginning stages, smelling heads was a sign of affection among Mongols, rubbing noses among the Maori and the Esquimaux, pressing mouths and noses upon the cheek and inhaling the breath, among the Burmese; and smelling heartily of each other while juxtaposing noses, among the natives of Samoa The informal controls represented by these and similar procedures can hardly be matched by those social techniques which, though historically nearer to us, are often less effective

Gestures, however, have been used for purposes of formal control in both primitive and ancient society Witness the civilities used to propitiate, in ceremonial, important personages, kings and gods Undressing to signify surrender had been a custom among Syrians, and to this day in Samoa the natives quickly strip themselves to their girdles as a sign of surrender The Batokas throw themselves on the back, roll from side to side, and slap their thighs while doing so, to say "You need not subdue me; I am subdued" Turks extend the right arm, move it down to the level of their heads, while stooping, and lower it again, to signify "I place this earth upon my head as a sign of submission to you" Joining hands overhead, and bowing, is an ancient sign of obeisance among the Chinese Stretching one's hands toward a person, and striking them together at even address, is used by the Congo natives to convey the impression of humility The Dahomans crawl and shuffle forward, walking on all fours, the Fundah and Unyanyembans put their palms together for the other person to clasp as gently or severely as he wishes—all to express obedience, humility and the reality of social control

The origin of these symbolic movements, varying with different peoples, is not always easy to find, in spite of the fact that they seem clear and simple to the members of the groups in which they are practiced In many cases there exists no logical relation between the gestures and their meaning This is true of our own as well as of the primitive gestures listed Thus for example, crossing fingers to ward off evil, among our own people, may appear simple enough, but actually we are at a loss to explain how or why such a sign was put into use And why do we shake the index finger when some one has displeased us? Why do we beckon to some one to call him over, as in the familiar "Hey, waiter!"? Why do we clench our fist when we are angry? Why do we wave the hand sideways to indicate negation?

J F Dashiell has traced these conventional gestures to meaningful acts which were gradually reduced to a few simple movements for convenience in communication Thus crossing fingers is probably the easiest way to symbolize a cross, and for that reason has been used to challenge the authority of the dark and evil powers Shaking a finger at some one, likewise, originated from the act of shaking up offenders who had placed others in an angry mood Clenching the fist is probably an abbreviation of the act of striking Beckoning to some one is a remnant of the act of pulling people by force Waving the hand sideways can be traced to the act of pushing others bodily aside. All these gestures are thus conveniences which are understood only because they had been fully expressed at one time. They are not merely conveniences, but genuine signs of social progress, for they take the place of acts which, in their

more extended forms, represent control through force.

These conventional gestures do not appear strange, because they are so common Other types of gestures, much less common, do appear to be strange We all know individuals whose personalities have been stamped with certain types of movements euphemistically called mannerisms These individuals twitch their shoulders, twist their faces, rhythmically close one or both of their eyes, and show similar types of behavior, irrelevant to both time and place, in response to a habitual form of impulsion which they can not inhibit These gestures are technically known as *tics convulsifs* or, simply, tics

Some time ago W C Olson, of Michigan, made a study of the tics of school children He watched the children in front of the classroom, and by the aid of a seating plan, a watch and a pencil kept careful record of all movements, such as putting fingers in the mouth, picking the nose, pulling the ear, fingering the hair, etc Only one type of movement was observed at a time, but every child who displayed the movement within five minutes was noted

Olson found that children behaved in very much the same way day in and day out, in spite of the fact that the observations were as much as a week apart Even a year later, his records showed, some of these habits persisted Olson discovered that children reproduce each other's gestures in certain parts of the classroom, thus spreading their nervous habits, but he did not claim that imitation was the only cause of their appearance Even more frequently the cause is to be found in persistent irritation and emotional shock.

Psychiatrists have been interested in the causes of tics for many years, and they have reported success in treating individuals afflicted with them An eminent psychiatrist of Baltimore recently described to me the case of a patient suffering from an uncontrollable shoulder-twitch In the course of treatment it was found that the patient had been frightened by a robber who had come up from behind Soon after this associated piece of evidence was brought out, the twitch disappeared By more or less protracted methods other tics have been removed Normal people also manifest movements which seem to be without cause These movements I have called *autistic* (or self-directed) gestures Thus, if we yawn when we are not in need of sleep, if we wet our lips when these are not dry, when we clear our throats though no cold or obstruction seems to bother us, when we suddenly get an urge to snap matches within our reach, or when we smooth our hair smooth enough to satisfy the most meticulous, do we mean to *say* anything?

Gestures of this type, because they appear to be directed to no one outside, can not be mistaken for the two types of gestures previously mentioned. They are not, like conventional gestures, intended to convey, by an established technique, some obvious meaning They are not, like tics, habitual in nature, taking place again and again, regardless of time or circumstance, and without relevancy to the behavior of other people Are they merely chance phenomena, "automatic" movements, occurring without special cause?

Behavior goes on all the time From the point of view of the observer certain acts may seem detached, but as a matter of fact there are no empty intervals of thought, no incidental acts, in living organisms There can be no irrelevant behavior from the point of view of the actor himself at least This is true, whether or not he can verbally or subvocally account for the logic of his acts What makes these gestures difficult to understand is not, then, their "automatic" nature First, it is the absence

of prepositions and conjunctions which might facilitate their translation into language symbols Second, though they may resemble words, they are explicit acts which are constantly interrupted by implicit acts such as thoughts, and other explicit acts, such as speech, with which they are continuous

Alexander Luria has pointed out that "irrelevant" gestures which appear together with other kinds of reactions are "motor storms," and that they indicate the presence of mental conflict In any conflict an individual is prepared to act in two or more ways, but always (unless disorganized) acts in one way only Acts that are not carried out are repressed Repressed acts become emotional attitudes or "complexes" These autistic gestures are traceable to complexes which are thus drained off, in spite of the solution which the conflict had received

In a series of carefully controlled experiments begun in 1931, the writer has shown that autistic gestures, in spite of their obscurity, constitute a legitimate and possible field of psychological investigation He has demonstrated that gestures can be studied reliably and that they recur in a given individual under similar conditions He has proved that autistic movements have an emotional background and that they have a genetic history not unrelated to the origin and goals of movement in the living organism generally He has found that these gestures bear a definite relation to personality types At present, by means of a somewhat intricate experimental set-up, he is attempting to prove that a certain group of gestures has similar meanings in various individuals These experiments proceed on the assumption that, first, there is always a cue in the situation which is associated with the gestures, and second, that the symbolism expressed in the gesture can be understood if we know something of the nature of the conflict which the individual experiences at the time he gestures

There are undoubtedly *general* meanings conveyed by these autistic gestures in individuals having conflicts which are similar enough to permit of their interpretation as a group Some gestures, for example, imply a suppressed attitude of resistance These gestures may be expected in individuals who can not demonstrate their hostile attitudes toward a social situation or some individual Inhibiting these attitudes, they present the picture of unconscious resistance, nevertheless As an illustration we might take clearing the throat A certain professional man, though a church member, is in a state of conflict with regard to the place of religion in his life On one occasion, while lecturing, he says. "We do not think of medical terms as final (pause) or sacred," clearing his throat It may be observed that the word "sacred" occurring with the phrase "medical terms," had reinstated and immediately evoked a state of secret opposition. This is typical of autistic gestures. The word which sets off the gesture may have no relation to the other words in the sentence, so far as the individual is concerned Hence, the total meaning of the sentence is destroyed, while a part of it, in the light of the individual's past experience, acquires special meaning

There are autistic gestures which seem to suggest that the individual evades the present situation, reminiscent of his conflict, by symbolically shutting himself out of it Recently a large daily carried an interview with a state's attorney under fire for favoritism to gangsters. The interview began with the following description

> Mr S was tired
>
> He hoisted his feet to the top of the work-table, pushed his spectacles up on his forehead, passed a large smoothing gesture over the lines of care in his massive countenance, and looked at his questioner with one of those searching looks which give you an uncomfortable feeling that the gazer is looking through you at some person behind you

Here we find the dominating gesture—

passing the hand over the face—to be essentially an escape, or at least an evasion, type of movement, in which the actor shuts himself out of the picture without actually leaving it

Finally, we might name a type of gesture in which the individual, unable to escape the situation and unable to meet it in any other way, recedes to an early pleasure-giving stage in which all things were possible Thus he can tolerate a situation which might otherwise prove intolerable A man who had sought the chairmanship of a college department, but was unable to secure it, squats down in the chairman's seat (as if to say I *eliminate* it), resorting to one of the earliest pleasure-giving postures which human individuals acquire The body truly *speaks* This man could express his conflict over the place which he had been eager to have not only without words, but without admitting his cravings to any one, including himself

These are but a few illustrations of gestural interpretation It will be observed that the specific reference of a gesture, even when so interpreted, is still left to be determined If there is resistance on the part of an individual at a certain point in conversation, why is it there? If the individual escapes from an unpleasant situation, why does he do so? These are matters which only a scrupulous analysis of an individual's background can reveal, with his own aid

There are other difficulties In the study of gestures, as in the study of all human behavior, we find individual differences occupying an important place We said previously that these unconscious movements might be similarly interpreted only to the extent to which we could equate or generalize upon human conflicts But some individuals manifest persistent gesture patterns which do not appear with similar frequency in other individuals, showing that, at least quantitatively, there is a difference Personality types, as determined by early development, possess modes of expression which differ from those of other personalities having conflicts of virtually similar general design Thus we see that the study of autistic gestures involves all the difficulties found in the study of human behavior generally and, besides, special difficulties due to their subtlety and unconscious nature

An opera-singer once asked the writer to teach him the meanings of gestures, so that he, the rogue, could understand the gestures which he believed certain fair ladies were directing at him Of course, this request was merely a projection of his wish that fair ladies might make secret representations to him, but, in any case, the writer had to beg off, for he realized that, under the conditions, many a lady might be accused of having motives of which she was not only unaware, but which she did not even have

A coed once told a college instructor that if he did not stop twisting, stroking and pulling a key suspended from his watch-chain, she would probably lose her balance In this case the instructor's gestures, in spite of their unwitting nature, obviously belonged in a system of interstimulation and response The young lady, at least vaguely, was aware that she was responding to the gestures, though neither she nor the instructor knew why *she* had responded to them as she had, why *he* had performed the gestures of which he was guilty, or what those gestures had meant Is a conversation of autistic gestures, then, an impossibility? The answer to the question depends on the extent to which we may expect others to interpret the autistic gestures that we make.

A moderate amount of training may enable a person to recognize the subtlest types of movement, in so far as direction is concerned. Lip-reading, with and without touch, has been found to be feasible. Again and again "mind-readers," or muscle-readers, have demon-

strated that it is possible, by placing hands on the head of some person who is informed as to the location of an object, and who is instructed to "think hard of where it is," to be guided to it by muscle movement Similarly, it has been found possible to select a certain card in a deck, tell a number of which the subject is thinking, locate a word in a volume or trace a pin in a room

The case of Clever Hans is too well known to need much description. The claims which had made the animal famous were properly modified when it was revealed that the horse could solve an algebraic problem even when the problem was written out in another room The prerequisites seemed to be that some one present know the nature of the problem When this was discovered, the head-movements of bystanders were recorded on a kymograph In spite of their minuteness, jerks ranging from one fifth of a millimeter upward could be detected by the horse without an intervening medium The perception of subtle cues is now an established fact

Barring cases of muscle-reading based on prearranged schemes, we may say that those other instances in which the detection of minimal cues has been found to be a reality, can be explained on the grounds of variation of touch and tremor, in cases where contact is provided Some expert "mind-readers," of course, may not resort to touch at all They depend more on auditory cues, such as nasal whispering, footsteps or changes in the subject's respiration. Where visual cues are used, changes of posture, movements of eyes and lips and various mimetic cues are resorted to In some cases the heat radiations of the subject's body have been found to be a source of guidance

In order to respond to a cue, however, one must be familiar not only with the direction of the cue, but with the implications of the cue in his own behavior The obtuseness of cats directed to an object by an outstretched arm or by the fixed gaze of their master is familiar to all who have dealt with cats. Neither will human individuals always respond to cues in their environment. The embarrassment of people who are given signs which have not been prearranged and whose meanings they do not understand, because they get no warmth of recognition from them, is well known to all What is true of language, of artistic paintings, of collective representations of unfamiliar groups is also true of gestures. In an ultimate sense we do not know what symbols signify, unless we know what conflicts originally forced their inhibition and symbolic existence

Theoretically, autistic gestures occur because they give us temporary relief from tension and conflict To gesture means to think frankly along certain lines, and to *express* our thoughts with impunity By means of self-directed gestures we can say things about ourselves which we are loath to regard as attempts at personal advertising We can, furthermore, say things about others, in their very presence, which we are loath to admit as possible The fact that we can act without admitting even to ourselves that what we do has meaning is precisely the reason that other people's gestures are beyond our comprehension We understand the conventional gestures of others, because our own conventional gestures are clear to us If we could understand our own autistic gestures, we might understand the autistic gestures of other people

SOME CRITICISMS OF COLLEGE EDUCATION

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In the last year or two several articles have appeared, mostly in our leading popular magazines, finding fault with our college education. Most of them have taken the ground that the college or university was not accomplishing what it should, that men of true culture were not being produced, and that the training given was narrow and not in keeping with the present advance of ideas and ideals generally.

On the whole, the articles seem to be destructive rather than constructive. Certainly the reverence for things past is to-day much less than it was a few years ago, and there is nothing particularly new or startling in the idea that we must discard what has been built up through years of effort and evolved by the human race by long and arduous experience. At present in Europe all the rights and privileges we used to think belonged to nations and peoples have been forgotten, and it seems, too, as if every principle of economics was abandoned for new untried ideas or for discarded old ones brought forward again as something original.

All we have to do is listen to some of the present-day music to appreciate what has happened to the established rules of harmony, counterpoint and form. No tonality, no vestige of a pure chord, violent and amazing rhythms. It may be a sign and symbol of the times that much of our music has become mechanistic and cubical, without significance of form. In the past as musical thought developed, we have had to modify our conception of what music should be, to give scope enough to allow a composer to completely express himself; which he might be unable to do in a more restricted form and medium. However, a slow development is one thing, but the sudden abandonment of all that has gone before is quite another thing. Our extremists in music to-day have discarded every rule and thrown away all that has been developed in the past, and started anew from the beginning. Such a procedure is not only a tremendous waste of the labor and work which we have inherited, but it is an actual loss of civilization.

What is civilization but a mass of data, knowledge and traditions left to us, which, instead of discarding, we should use and try to improve upon? Why do we admire one work of art more than another? Because we have been educated to certain standards, left by the great artists of the past, and we compare new works with these old standards. We may not know that we are doing so, the process of comparison may be entirely unconscious, but if it were not for these standards, we should simply be uncivilized.

Of course, standards may change or be wrong. The psychologist speaks of "fixed ideas." Take, for example, the enormous debt which has been put on this country in the last few years. For a time everybody was talking about it, and we deplored and condemned it because everybody else did, but now we begin to take for granted that it must be, at least we hear little or nothing said about it. We accept it because everybody else accepts it. However, because some of our standards may be thoughtlessly accepted, it does not follow that we do not have standards or could do without them.

The above is merely given as an illustration of what has occurred in one department of art. Many other examples

could be quoted, for our whole philosophy of life seems to have become unsettled and confused. Perhaps this is an aftermath of the terrible suffering the world war caused, and which by pushing us back towards a barbarian stage has brought out again those primitive instincts and passions that are still deep down in us all Whatever the cause, there is a great tendency everywhere to abandon all conservatism and for our liberals and radicals to become anarchists Is it any wonder, then, that the field of education has come in for its share of criticism?

There is no doubt that institutions of learning become rigid or crystallized They have, through long years of experience, found that certain methods and procedures in teaching are good, and naturally they hold to these standards which they have set up and in which they have confidence An individual or small group of individuals can easily change ideas or view-points, but our established colleges do tend to get into an inflexible mold, so that any considerable change must come about very slowly And gradual changes in educational matters are taking place For example, of late years our technical and engineering colleges have introduced more and more general or so-called "cultural" studies among the strictly technical ones We also find the idea growing that civilization is likely to go to pieces unless man can be motivated by reason instead of by emotion If it were possible to replace our politicians of to-day by men who had a scientific attitude of mind, our problems of government and society would be attacked in a more logical and less emotional manner Selfishness and dishonesty will probably always be with us, but a true scientist can not accept what he knows to be false and wrong, otherwise he is not a scientist. Furthermore, he studies the problems in an impersonal way Enough men of this type would bring order out of a chaotic world. Some of our colleges are introducing courses in social science to accomplish such results. For example, the Carnegie Institute of Technology has established the Maurice Falk Professorship of Social Relations

If our colleges really have become as rigid as some persons allege, let us consider in detail a few of their criticisms. The first is that the college is going blindly ahead and does not know what its objective is. In other words, have we an objective, and what are we trying to do in education?

Of course, it goes without saying that we are trying to educate our students; but the word "educate" has such a wide dictionary definition that it means different things to different people Perhaps most of us would agree that we are primarily trying to develop the student. A general conception of the process of education might be somewhat as follows. The student comes to college with an unformed mind, lacking in logical opinions, unsure of his knowledge, with his values of life and things in general uncertain; and after four years of study and training he has acquired "poise," developed his opinions, corrected his values of life and molded his character In other words, he has learned how to study and how to think and reason

Perhaps most educators would accept in a general way some such statement as a definition of the aim and meaning of education, and so perhaps this answers the question of what the colleges are trying to do, at least, so far as their fundamental objective is concerned But although we may know what we want to do, how to do it is the real question; and here it is that opinions and ideas differ greatly On the one hand, some believe that the kind and type of subject taught to the student makes no difference whatsoever; on the other hand, some want nothing but scientific subjects given; while others would replace these with the

so-called cultural studies And so it goes, with all sorts of opinions, even to the advocate of physical education who believes that it should have the most prominent place

A second criticism made against the college is that it does not make useful men. Of course, such a generalization would be impossible to prove Just what usefulness is, and whether college men succeed better in life than those without a college education, would involve a definition of "success" Counts of the number of college men listed in "Who's Who" and lists of college men receiving high salaries may be illuminating, but not conclusive proof There is an impression among many people that a college education may make a happier man, but spoils him as a money maker and a successful business man Without spending time over such a controversial statement, consider the following experience of a dean in one of our large engineering colleges

This dean was sitting in his office one day when in came a man who had graduated from this institution some two or three years before The graduate said "Dean, why don't you put more technical studies in your engineering courses? What a man needs when he gets out in the world is a knowledge of things that can be turned to use and that will make him more valuable to his employer"

The next day a graduate who was considerably older and had been graduated some fifteen years came into the dean's office He said: "Dean, I can't understand why it is that you put so many technical subjects into your courses. What a man needs is not so much technical matter, which he can not help picking up in his practice, but broader subjects which he can not easily get outside of college."

The third day a man who had been graduated some thirty-five or forty years came in He said · "Dean, I tell you what you ought to put into your courses, and that is philosophy."

In discussing what kind of studies and training should be given (and this is particularly true of the technical school), the question always arises. Why can not the student's mind be developed by studying useful subjects? Or, to state it in another way How much of education should be devoted to training the student to make a living? The economic side must of necessity be of interest both to the student and to industry Ask the ordinary engineering student why he chose to go to a technical instead of to an academic college, and the majority of answers will be, because he thinks that the technical school will fit him for a job after graduation And even if the student is not thinking actually in dollars and cents, he still has an underlying feeling that it gives him a profession or vocation, which really is an economic reason. A great many young students have somehow gotten the idea that education is a matter of acquiring a great mass of facts, and that is all that is necessary to assure making their fortunes after graduation Thus the economic problem is one which young men are thinking about, and the educator can not safely neglect it

If the above-mentioned dean were asked if he considered cultural studies necessary in an engineering course, he would undoubtedly say that he did. He might give as his reasons that men who study in one field only become highly specialized and narrow, and that they lack breadth of knowledge and do not appreciate the bearing or influence of other fields on their own Furthermore, such subjects as literature, history and the like round out the student and help greatly in developing his character, show him how to get more out of life, and interest him in human affairs and make him a better citizen generally

This is the type of argument usually advanced; but the dean might have taken

a very different line He might have argued from a very practical standpoint. Take, for instance, a graduate who has a good technical knowledge, but knows little of literature and who has a poor command of English. This is not by any means the chance student, for any one familiar with our great technical colleges knows that such a man is quite a common product As some pessimist has said, "He can not write, he can not read, all he knows is gears and wheels" It is not as bad as this, but this type of graduate we all recognize If such a man is to remain a mechanic and work by himself over inanimate things, he may keep along the even tenor of his way, but suppose he is taken into an office and asked to write the specifications for a machine He can not do it, not because he lacks the technical knowledge, but because he can not express his ideas in English In other words, it does not make any difference what his technical knowledge is, to be of value to his employer he must also know English

Suppose again this man is asked to sell a machine As we all know, there is something besides technical knowledge that makes a salesman Broadly, there are two types One type of salesman comes to his customer and says "Here are the specifications for the engine you need I do not know much about them, but my firm turns out the very best engine made Come along and have lunch with me." The other type may not have address enough to ask a customer to lunch with him, and would not know what to do if he did, but he may know the details of the engine perfectly

Now which of these men will sell the engine? It may depend somewhat on the type of buyer, but generally, the man who can talk, in spite of his technical ignorance We see this everywhere, the man who knows the most is not the man who sells the most As a soap manufacturer says: "Any fool can make soap, but it takes a genius to sell it"

Take, for example, a prospective customer of the nervous type who has a long, thin face Such a man is quick in his movements and actions, and not only is he quick physically, but he is a quick thinker as well This man will not listen to the details of a long specification He wants to jump at his conclusions, and if you suggest things to him, letting him give you the answer, he is often flattered. Whereas the man with the large, square face, more of the lymphatic type, is generally a slow thinker and will follow your explanation through detail after detail. It would be useless to explain a blueprint to the first man, while the second will be interested. Between these two extremes there is every combination

One of the most successful technical salesmen this country has produced started out as an office boy in an eastern railroad office He never had any scientific training, and what little technical knowledge he possessed he picked up as he went along But he had that wonderful intuitive knowledge of human nature that is so rare When he talked with a customer, he unconsciously felt the type of man he was talking to, and somehow fitted himself into the man's mood. Every one liked him He had that intangible thing we call "personality."

Do not misunderstand nor think that this is written in disparagement of technical knowledge Not at all, for the ideal salesman must combine technical knowledge with a broad human knowledge Superintendents and operating men often have a tendency to look down on the technical salesman, but after all, is not the president or high official of a manufacturing concern a good salesman? One of the reasons why he is where he is, is that he can "put over" his ideas Whatever truth there is in the old saying, "Salesmen are born, and not made," it is certain that the college can help a very great deal in developing what talent the student has

The above is merely a strong argument

for introducing more cultural subjects into our engineering colleges, and also for broadening the student as much as possible. Many students get as much perhaps by contacts with other students and with teachers as they do from studies, and certain college activities also help to broaden the student's horizon A truer estimate of a student can generally be obtained from his fellow students than from the faculty, because the student body in their judgment takes into account all those qualities which go to make up his character and personality, while the faculty, knowing his scholastic attainments better than his other qualities, judge him in a narrower way

So breadth of knowledge is necessary in the engineer, as well as technical information Not long ago the head of one of our large industrial corporations made the following statement "We can get plenty of men who are technically competent, who are careful and thorough in their investigations, whose conclusions are sound, but who can not make a favorable impression before a board of directors We can get plenty of lawyers who, after being properly coached by our engineers, can glibly and even convincingly talk to the same board of directors, until some question is asked which has not been covered in the process of coaching, then they too flounder about If we could secure a man who possessed the conscientious thoroughness and accuracy of the engineer, and also the facility of expression and persuasiveness of the lawyer, we could afford to pay him any salary he might ask"

Obviously, therefore, a college must do something beside teach specialization A compromise must be made to meet the needs of various students Referring again to the above three men who interviewed the dean, each of these men had his needs The youngest man had to make a living, the older man, in a responsible position, was not interested in details but in breadth of view, while the last man had perhaps become more interested in the broad principles of life It would seem, then, that there is a cycle that most graduates go through in after life And this seems quite a reasonable conclusion, inasmuch as almost everything we know of goes in a cycle, from a solar system down to human life, and as education is part and parcel of our life history, as a man gets on in life his knowledge and outlook change It is a commonplace that men of the same age naturally find more in common to talk about. Old men do not as a rule associate with young men

One other criticism which has been made against the college is the lack of thoroughness of teaching, and this is perhaps the most valid of all the criticisms and the hardest to answer It may be that many of our educational institutions try to cover too much ground Specialization and the constantly growing body of knowledge have placed the college in a very difficult position This is especially true of engineering colleges, for they feel that a certain amount of ground must be covered by the student and the tendency is to jam him over it We sometimes lose sight of the development and training of the student's mind, by thinking that the necessary thing is to fill him up with knowledge To push a student over ground but half understood surely is not properly education at all In addition, it teaches him bad and careless habits of thought and produces a mind improperly trained One subject which the student has really grasped is worth more to him than the hazy smattering of a great many. Is not a scholar one who knows what he does know? It would be a great deal better to cover less ground, and make sure that what is gone over is really understood Suppose we do not teach as many subjects No college can turn out a finished man in any line The graduate will find, no matter what he takes up, that further study is necessary. If a cer-

tain subject has not been covered in his college course, he can, if he has the proper fundamental knowledge, get it for himself. No college can cover all human knowledge, and education does not stop at graduation

Of course, the personality and experience of the teacher count, but after all, no matter how good the teacher, he must be given the necessary time to present his subject and the student the necessary time to properly digest it. Every teacher knows that there are certain students who get along with enough coaching to pass routine examinations, but who really have no true grasp of the subject

Some day the college course of four years may be lengthened, and there are a large number of students to-day who take postgraduate courses Many students go first to an academic college, and then finish in a scientific or technical college However, many valid objections can be raised against increasing the time spent in college, and it seems likely that we will retain the present four-year length for college education at least for the present. At any rate, the best way to improve our education would be to teach less, but teach thoroughly what we do teach.

Summarizing what has been said·

(1) College education is fundamentally a matter of student development, not of the amount of knowledge acquired. It is not the accumulation of facts, but a training in methods of thought. Facts can be acquired outside, but the function of the college is to teach how to reason and think Most colleges do this at the present time; and therefore the criticism that the college has no objective is not a valid criticism

(2) The idea held by many people, particularly young engineers, that cultural or liberalizing studies have no practical value, is entirely wrong On the contrary, they have a very great practical value and help directly in making a living Criticisms that our colleges do not turn out useful men are not well founded.

(3) It is better to teach a few subjects thoroughly, rather than to try to cover a certain amount of ground regardless of quality Such methods make careless and inaccurate men Criticisms of this kind do have a certain validity. Some of our colleges, particularly some of our technical schools, seem to believe that the student is not properly trained for his profession, unless a certain ground has been covered Such criticisms are profitable and constructive

BOOKS ON SCIENCE FOR LAYMEN

CIVILIZATION AGAINST CANCER[1]

Dr. Little has undertaken a difficult task in assuming the burden of instructing the layman in modern aspects of cancer research and at the same time outlining for him the difficulties which arise in schemes for cancer control—difficulties which are not only financial but also human In so doing he has produced a readable book and one rather brimming with optimism In fact one gets the impression that we are very much "on our way" toward speedy control of this group of diseases—an attitude less shared by those who have to face the ever-increasing mortality figures from cancer Still it is impossible for one who heads the American Society for the Control of Cancer to assume a pessimistic mood toward the problem to which he has dedicated himself

The book arouses several reactions in the mind of the reviewer How impossible it is for the individual to follow Dr Little's advice to "Train yourself to overcome fear by disciplining your mind to face and consider the possibilities of cancer before they become actualities " The average human being just won't do this His mind can not be trained to anticipate lethal disease, and a brain so conditioned is a psychiatric problem Again, there are the rules for increasing one's chance of avoiding cancer The first three rules pertaining to oral cleanliness and dental hygiene, removal of certain moles, and protection of the skin from excessive solar radiation, are sound and firmly attested by long experience The remaining five, although usually stated as means of avoiding cancer, are, with the possible exception of the seventh, which pertains to gynecologic hygiene, wholly vague and unconvincing. Tight brassières are mentioned In the old days it used to be the steel corset stay, but now that menace has been removed by stylists and yet we have the same incidence or possibly a higher incidence of mammary cancer The relation between gastric cancer and overeating is improbable. Did not primitive man gorge and do not less civilized peoples stuff when the occasion arises and otherwise fast? The feeding habits of English royalty in the days of the eighth Henry, as portrayed by Charles Laughton, seem to have been such that they all should have died of gastric cancer, and as for the effect of concentrated urine on development of bladder cancer one must remember that the dog is a source of experimental betanaphthylamin bladder cancer, and yet no animal according to common observation has less tendency to retain urine in the bladder than has man's best friend.

These musings of the reviewer only go to show how vague the causes of human cancer really are When we come to experimental cancer, be the predominant factor heredity or be it a phenanthrene ring compound, we are on firm ground at least so far as present knowledge extends, and the contrast between that sort of knowledge and rank medical superstition is obvious from Dr Little's book Speaking of medical superstition, Dr. Little's illustration of the stuffiness of meetings of distinguished medical men is refreshing to the initiated

A notable event in the annals of cancer took place with the presentation of Peyrilhe's essay before the Lyon Academy in the late eighteenth century—an essay written in response to the question, *Qu'est ce que le cancer?* Dr. Little's book answers it again for the layman and shows the progress made since that day, and above all how far we still must go before humanity can be satisfied. The humorous excursions of the reviewer do not detract from the value of the book

Fred W Stewart

[1] *Civilization against Cancer.* By C. C. Little. vi + 750 pp. $1.50. Farrar and Rinehart

FUNDAMENTALS OF THE PETROLEUM INDUSTRY[1]

The experience of the author, primarily in the production of petroleum,

[1] *Fundamentals of the Petroleum Industry* By Dorsey Hager. Illustrated. xvii + 445 pp $3 50. McGraw-Hill Book Company

qualifies him for undertaking a comprehensive general treatise on the petroleum industry. Although the first three chapters, dealing with the place of petroleum in modern world economy, the history of the industry and the corporation organization of the industry as a business, are neither as well written nor as well organized as later chapters of the book, they contain a considerable amount of statistical data illustrating the growth and present importance of the industry The 13 billion dollar investment in the industry in the United States and the estimate that the energy obtained from crude oil is more than ten times the energy obtained from water power in the country are among the data given as proof of the importance of petroleum

Mr Hager has arrived at a more optimistic point of view regarding the future supply of crude oil than most experts in this field, but his method of approach to the problem is interesting He points out that exploration has been more extensive in the United States than in any other country and that the area of the United States is about one fourteenth that of foreign lands, excluding Greenland and other polar lands covered with ice sheets He then applies this factor to the estimated future oil recovery of the United States to obtain a rough estimate of the future reserves to be discovered in the world as a whole. Two criticisms of this method of approach are immediately apparent First, since the original oil reserves in most foreign fields have been only slightly depleted, a more correct base for the application of the area factor would be the ultimate recovery of the United States, composed of about 20 billion barrels of past production plus the estimated future production

Second, a more fundamental criticism may be made of the use of total land areas as a basis of comparison As is shown by the tabulation of proven reserves for the United States prepared by the American Petroleum Institute and included in Mr Hager's book, about 80 per cent. of the total is available in Texas, California and Oklahoma As is well known to petroleum geologists, the great accumulation of oil in these states is due to the presence of basin areas in which great thicknesses of young and slightly altered marine sediments remain. There is no present basis for anticipating the discovery of important oil reserves except in areas having similarly favorable regional geologic conditions

The sections of the book on the amount of oil recovered per acre and the acquisition of oil lands and royalties should serve to show a potential investor in properties of this sort that there is a wide range in their value and that investments should be made only after approval by competent experts Although the business of producing oil and particularly of drilling and completing wells is given much greater emphasis and in much greater detail than is justified by its place in the industry as a whole, this lack of balance reflects the experience and point of view of the author and may conform to the relative interest of the average reader These chapters are well organized and well written

The chapters on transportation and storage would have been more useful if the accessibility of the major oil-consuming eastern industrial region to marine transportation and the advantage of cheap ocean transport for petroleum to fields near tidewater both in the United States and in foreign countries had been fully discussed.

The chapter on oil refining would have been improved by a few paragraphs pointing out the relationship between refining methods and crude oil requirements Due to improvements in refining processes there is to-day less difference in the refining value of different types of crude oil than at any previous time The author might well have discussed at more length the effect of changes in refining methods on the demand for crude oil

Not only does cracking produce more gasoline per barrel of crude oil, as pointed out by the author, but improvement in the burning characteristics of the motor fuel produced has enabled motor manufacturers to design and build motors with higher compression. Such motors have higher efficiency and tend to reduce crude oil requirements

In summary, although as indicated "Fundamentals of the Petroleum Industry" would be improved considerably by a different treatment of some of the subject-matter, it is mainly sound and well written. It merits reading by those interested in this important industry.

GAIL F MOULTON

FROM MUSCLE TO STEAM[1]

ONE has only to read this excellent book to realize what a transformation of the world has been brought about in 150 years and mostly within 75 years by steam and electricity Although the author has written a straightforward account of the development of the steam engine from the time of the experiments with air pumps by von Guericke (1602–86) to the present time, fortunately he has done it with such clarity and with so many human touches that his story will be as interesting to the layman as to the scientist No one can read that story without realizing that during the past two centuries the human race has passed through the most important period of its history Nor will one doubt that in the perspective of some distant future the political struggles that have attracted, and now attract, the attention of the world have been of relatively trivial importance

It is generally believed that James Watt, after noticing steam raising the cover of a tea kettle, was suddenly inspired (1765) with the conception of the steam engine and constructed one That story is on a parity with the one that a falling apple led Newton to the discovery of the law of gravitation As a matter of fact, approaches had been made to the principles that underlie the steam engine for nearly 100 years Among those who were working on the problem Thomas Savery (1650–1715) and Elias Newcomen (1663–1729) stand first Each produced and operated complete engines

Both Savery and Newcomen made use of the pressure of the air instead of the pressure of steam to operate their engines They first displaced the air in cylinders by steam and then condensed the steam The great advance in principle introduced by Watt in 1765 was that he employed the pressure of steam against the pressure of air on the opposite side of the cylinder head, and later steam engines used both principles

There is a wide-spread belief, due in part to recent governmental propaganda, that water power is not only much cheaper than steam power but a rival of it In 1929, according to figures released by the World Power Conference, 79 1 per cent of all mechanical energy generated in the world was produced by coal, 15 7 per cent by petroleum and only 5 1 per cent by water The installed capacity of water power, however, was about 60 per cent of that of steam, the low production of energy being due to the fact that generally water power is seasonal In that fact lies its relatively high cost

As interesting as the early history of the steam engine is, it is no more fascinating than the recent developments of high pressure boilers and steam turbines Since all these phases of the evolution of the steam engine are thoroughly covered by the author, including quantitative results, the book gives a valuable survey for the engineer, as well as a thrilling story for the intelligent person who is interested in the forces that are molding our civilization

F R M.

[1] *A Short History of the Steam Engine.* By H W Dickinson xvi + 255 pp, 78 figures + x plates. Cambridge University Press (Macmillan Company) $3 50

DR ENRICO FERMI

THE PROGRESS OF SCIENCE

ENRICO FERMI—NOBEL PRIZE MAN IN PHYSICS FOR 1938

THE award of the 1938 Nobel prize for physics to an Italian physicist, Enrico Fermi, surprised no one, for he was as clearly marked for attention by the awarding academy as was, for example, his sole Italian predecessor, Guglielmo Marconi, when he received the award in 1910. The immediate basis of the award to Fermi was the discovery of atomic transmutations that can be brought about by the addition of neutrons to the nuclei of atoms, and the brilliant series of experimental researches on these transmutations and on the properties of neutrons which he, with his collaborators, accomplished at the University of Rome in the years 1934 to 1938. The production of many kinds of new radioactive atoms, the discovery of the effectiveness of slow or practically stationary neutrons in combining with surrounding atomic nuclei to form these new radioactive atoms, gave an enormous stimulus to research on the nature of the nuclei of atoms, the story of which can not be attempted here.

Fermi is 37 years of age. He was a Roman boy and attended the usual succession of schools in Rome. At the age of thirteen he developed a great interest in mathematics. Guided by an engineer friend he read and mastered more mathematics, even before he went at the age of seventeen to the Scuola Normale Superiore at Pisa on a scholarship, than he was required to learn in attaining the doctor's degree in theoretical physics. From boyhood he had also a lively interest in experimental physics. Few of the Nobel prize winners in physics have been men so thoroughly at home in both theoretical and experimental research.

After graduating from Pisa in 1922 he went to Gottingen to study, principally with Max Born, for seven months. It was the time just preceding the development of wave mechanics and the uncertainty principle, when the quantum theory was being deeply studied and discussed. Heisenberg, who was to make such important contributions within the next two years, was a fellow student. A year at the University of Rome came next, then came a visit to Leyden, where, with Ehrenfest, Goudsmit, Kronig and others, Fermi matured and developed self-confidence. For the next two years Fermi had an appointment at the University of Florence, where he began his major contributions to theoretical physics by developing what is known as the "Fermi-Dirac statistics," which extends to the motions of the molecules of a gas the already known fact that in an atom no two electrons can exist in the same quantum state. This became of especial importance when applied to the electron gas in a metal.

In 1926 he went back to Rome as professor of theoretical physics, continuing at first mainly theoretical investigations such as his notable development of a theory of β-ray radioactivity, based upon the hypothesis of the existence of the *neutrino* or uncharged particle of mass very small compared to that of an electron.

From 1930 on he has visited this country often, usually to lecture at the University of Michigan Summer Session, though he has taught also in summers at Stanford and Columbia.

Very direct and clear in his thought and speech, sincere but not too serious, using few unnecessary words, he is recognized as an outstanding teacher. In experimental work also he achieves the direct and simple approach, and in his discoveries he exemplifies well the fact that only the clearest minds can for the

first time do the things that immediately thereafter are so simple and obvious for any one.

After his visit to Stockholm last December to lecture before the Swedish Academy and to receive the Nobel prize in physics, at the same time as the American writer Pearl Buck received the Nobel prize in literature, Fermi came directly to the United States to be professor of physics in Columbia University, where since January he has been engaged in active research on the splitting of uranium atoms. In coming, in response to a long-standing invitation, to make his home in this country, Professor Fermi brought with him his wife, Laura, daughter of an admiral of the Italian Navy, and their two children, Nella and Giuglio. Mrs. Fermi has followed closely her husband's work, and has herself, together with the wife of Fermi's Roman colleague Amaldi, written a popular book, "Alchimia del Tempo Nostro," on Fermi's discoveries.

GEORGE B. PEGRAM

DR. HUBBLE AND ALBERT SAUVEUR, FRANKLIN MEDALISTS

Two trail-blazers in science, one whose concern is with the infinite and the other with the infinitesimal, were recently honored by The Franklin Institute at its annual Medal Day exercises. Dr. Edwin P. Hubble, who is largely responsible for the exploration of a thousand million times as much space as was known a score of years ago, and Albert Sauveur, father of metallography in America and until his recent death the dean of this country's metallurgists—these two were named as recipients of the highest award the historic Franklin Institute can bestow. The presentation was made posthumously to Sauveur, his widow accepting the medal and certificate for her late husband.

Dr. Hubble, at the eyepiece of the world's largest telescope, made "investigations upon the nebulae, which surpass in extent, variety and success those of any other astronomer, past or present. . . . These investigations have extended the spatial frontiers of human knowledge in a greater proportion than any others in the history of science."[1]

Born at Marshfield, Missouri, in 1889, Dr. Hubble majored in mathematics and astronomy at the University of Chicago, where in 1910 he won a Rhodes scholarship. For three years he studied at Oxford, receiving in 1913 his degree of master of arts in jurisprudence. On his return to the United States he was admitted to the bar in Louisville, Kentucky, but the following year concluded that his strongest interests remained in scientific work. He resumed his study of astronomy, became an assistant at the Yerkes Observatory, and in 1917 received his doctor's degree.

At that time he enlisted in the infantry and served in France until 1919, when he was mustered out with the rank of major. He immediately joined the staff of the Mount Wilson Observatory, with which he is still connected.

In his studies of the galactic nebulae, Hubble has shown that these diffuse, irregular clouds shine by light reflected from neighboring stars. When the star is one of the "later" spectral type—cooler—the light, reflected from nebular dust clouds, produces a continuous spectrum, but when the stars are of an "earlier" type—with a surface temperature of more than 20,000°—their short-wave ultra-violet radiation excites the atoms in the nebulae, which then glows with a typical gaseous bright-line spectrum.

Working with the 100-inch telescope, Hubble has studied the spiral and other extra-galactic nebulae, and has shown that they are huge star clouds, compar-

[1] Dr. Henry Norris Russell, October 27, 1938.

PRESIDENT PHILIP C STAPLES PRESENTING FRANKLIN MEDAL TO DR HUBBLE

able to our own Galaxy He discovered in them Cepheid variables which have enabled him, by means of Shapley's period-luminosity relationship, to calculate the distances of the spirals He has estimated the distances of the fainter and more remote clusters as 200 to 500 million light years

A study of the red shift in the spectra of the nebulae confirmed the relation between distance and apparent velocity of recession Hubble suggests that this shift may be due to some other cause than velocity of recession, and it is possible that a solution to this problem may come with the completion of the 200-inch telescope

Sauveur, at the eyepiece of his microscope, began at an early age to study the structure of iron and steel, pointing the way for modern routine testing and research in industrial metals He "taught the users of steel to use a microscope—something that users didn't know He found all kinds of things in the steel that oughtn't to be there—like looking at a drop of water under a biological microscope He put metallography on the map when he founded and edited *The Metallographist* in 1899, afterwards the *Iron and Steel Magazine* "[2] He is generally regarded as having been the father of the science of metallography in America, and among metallurgists was affectionately known as "the Dean "

He was born at Louvain, Belgium, in 1863, and came to this country after completing his preliminary education in the School of Mines in Liége, and received his bachelor of science degree in mining and metallurgy from the Massachusetts Institute of Technology in 1889

His first position was with the Pennsylvania Steel Company, where nobody seemed to know what should be done with a metallurgist, so he was assigned to a place in the chemistry laboratory He

[2] William Campbell, *Mining and Metallurgy*, August, 1935

ALBERT SAUVEUR

was left pretty much to his own devices, and spent the greater part of two years in studying the metallurgy of iron and steel In 1891 he went to the South Chicago plant of the Illinois Steel Company Here was found an old microscope, and a barrel was made to serve as a laboratory table while waiting for other equipment to be procured In this manner was begun the work which was destined to play a major rôle in the manufacture and heat treatment of steel From the time that Sauveur began his studies, the importance of this type of investigation has continually increased, and metallurgy, as a modern science, owes much to this new avenue of study

Photomicrographs of polished metals became a standard process of investigation As early as 1893 he presented some of his findings on the relation between chemical composition and heat treatment before the Chicago meeting of the American Institute of Mining Engineers.

An international milestone in metallurgy was his 1896 paper on "Microstructure of Steel and Current Theories of Hardening" This contribution aroused tremendous discussion in this country and in Europe

In 1899 he went to Harvard University as instructor and was assistant professor in metallurgy and metallography from 1900 to 1905 He was lecturer at the Massachusetts Institute of Technology until 1903 He became a professor at Harvard in 1906 and held that post until he retired from active teaching in 1935 His texts and scientific writings have been regarded as classical works in his field Honorary degrees and awards were showered on him by universities and learned societies here and abroad During the war he served in France as an aeronautical metallurgist, connected with A E F He was United States delegate to the Pan-American Scientific Congress held in Lima, Peru

The Franklin Institute's decision to honor him was made shortly before his death in January, 1939, and the medal and accompanying certificate were therefore presented to his widow

A S

A HOSPITAL GROWS UP—MEMORIAL HOSPITAL IN 1939

The Memorial Hospital for the Treatment of Cancer and Allied Diseases, of New York City, had its formal opening at its new site on June 14 The new home occupies the block at East 67th and 68th Streets between First and York Avenues, directly across from the Rockefeller Institute for Medical Research and the Cornell Medical College and New York Hospital Memorial Hospital's affiliation with Cornell Medical College, of many years' standing, is now more direct since moving into the district of the Cornell Medical Center

The block on which the hospital is built was personally acquired over a period of years by Mr John D Rockefeller, Jr, for this purpose, at an approximate cost of $2,500,000 The General Education Board gave $3,000,000, and Mr. Edward Harkness gave $500,000 for the building program An additional $300,000 was spent on new, special equipment; so that the total cost of the new Memorial Hospital, together with its large supply of radium previously purchased, stands at about $8,000,000 This, according to a statement made by Dr Ewing many years ago, approaches the amount of money which the ideal, properly equipped cancer institute should cost

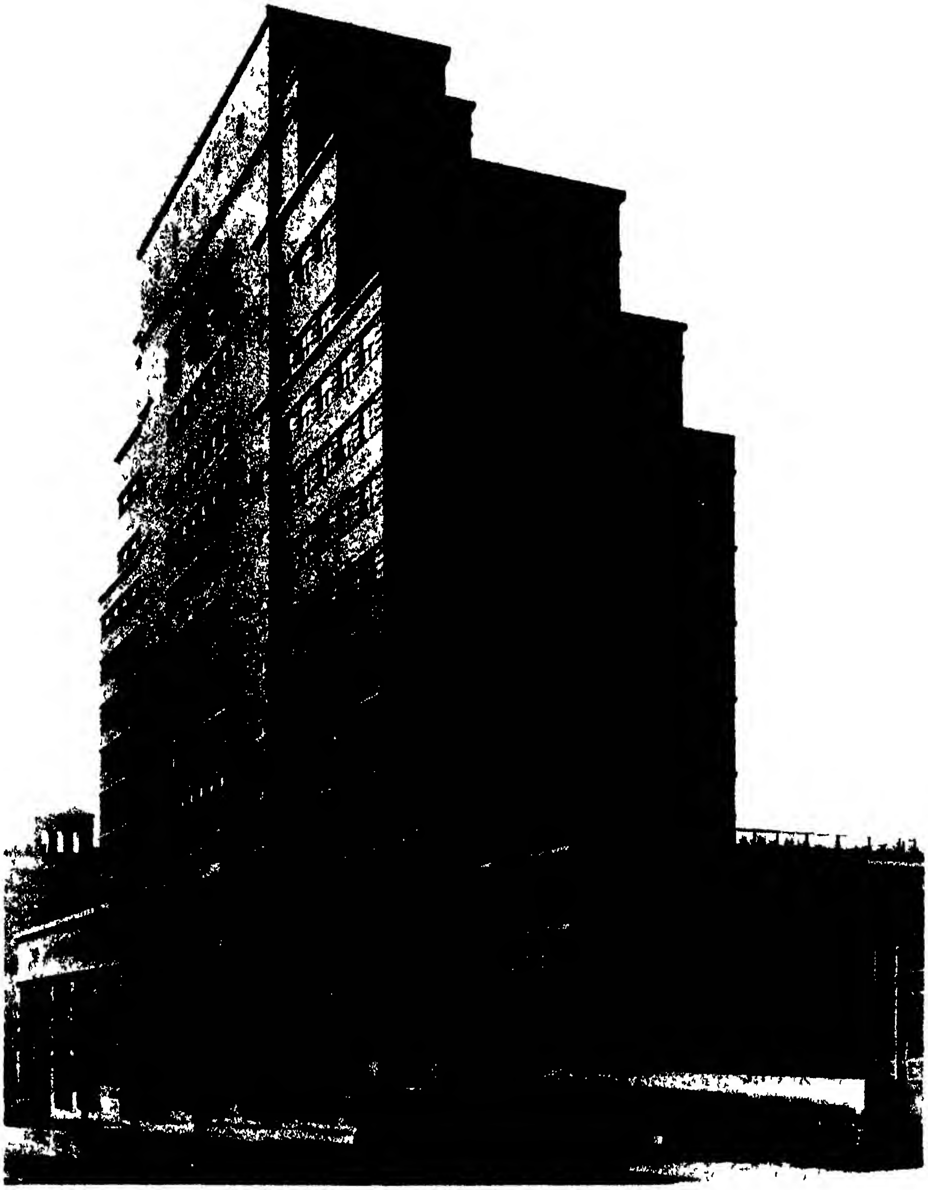
Due to the able leadership of Dr James Ewing, for the past twenty-five years its director, Memorial Hospital has taken on the rôle of a leader of thought in the international field of cancer This reputation has come as a result of its cancer researches in the laboratories of biology, physics and chemistry, as well as the development of greater refinements in cancer diagnosis and technique of treatment To-day it stands as a cancer institute of national significance

The program of the hospital opening consisted of a private dinner, on June 13, to Mr John D Rockefeller, Jr, held in the nurses' dining hall Seventy intimate friends of Mr Rockefeller and of the hospital attended The speakers were President Day, of Cornell University, Mr Walter Douglas, chairman of the board of trustees of the hospital, Dr James Ewing, its director, the Honorable Jacob Gould Schurman, president of Cornell at the time of the affiliation of Cornell and Memorial, and Mr John D Rockefeller, Jr

On the morning of June 14, a scientific meeting was held in the large, handsomely decorated auditorium of the new hospital At this meeting, Dr Burton T Simpson, director of the New York State Institute for the Study of Malignant Diseases, at Buffalo, discussed "The Pioneer Cancer Institutes in America" He spoke of the significant contributions made by the Memorial Hospital staff, and compared the work of the various early cancer hospitals Dr Frank E Adair, attending surgeon and executive officer of Memorial Hospital, in "The Position of a Cancer Institute in Relation to the General Medical Profession," outlined the three major lines of attack on the cancer front as they are being carried forward by the American Society for the Control of Cancer, the American College of Surgeons (in their 272 cancer clinics) and the special cancer institute, such as is represented by Memorial Hospital

Dr Lloyd F Craver, attending physician and chairman of the fellowship committee of Memorial Hospital, spoke on "Graduate Education in Memorial Hospital," showing that there is a great demand for men specially trained as experts in diagnosis and treatment of cancer Dr James Ewing, director of Memorial Hospital, spoke on "Planning the Memorial Hospital Building," in which he contrasted the construction problems of an ordinary general hospital with the special problems which surround the maintenance and servicing of such an electrical and radium plant as the new Memorial William D Coolidge, Ph D, director of research laboratories of the General Electric Company, spoke on "The Contributions of the Physical Sciences to Cancer Therapy," outlining the development of the older therapy equipment with the new units installed in the new Memorial

In the afternoon, the hospital was declared formally open for service by the president of the board of trustees, Mr Harry Pelham Robbins At this service, other speakers were Dr. Ludvig Hektoen, director of the National Cancer Council of the United States Public Health Service, Dr Sigismund S Goldwater, commissioner of hospitals of the City of New



THE NEW MEMORIAL HOSPITAL

York, and the Honorable Jacob Gould Schurman

The Memorial Hospital has certain new features of interest The x-ray therapy department is probably the largest in the world, extending completely across the south side of the hospital along 67th Street It contains a million-volt "pocket edition" type for deeply situated cancers, five 250 K V therapy machines with easily adjusted portal openings, a new invention of Dr. Gioacchino Failla, the physicist, four 200 K V therapy machines, and two low voltage therapy machines Apart from the large amount of x-ray diagnostic and therapy equipment, the hospital has nearly ten grams of radium It was this large radium supply which helped build up the reputation of the hospital many years ago The second floor has huge space for the laboratories of physiology, biology, chemistry, physics and biophysics It is anticipated that with the improved housing of the laboratories renewed vigor will be thrown into the work of the fundamental researches of cancer

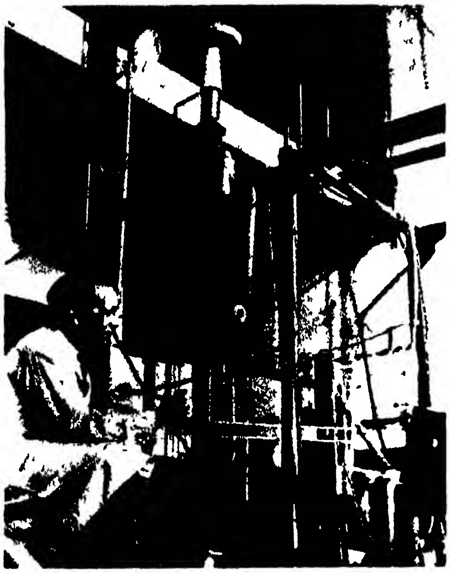
FRANK E ADAIR, M D

THE ELECTRON MICROSCOPE

UNDER substantially the above title Dr V K Zworykin presented a paper at the Virginia meeting of the American Association for the Advancement of Science which was of great interest from both the theoretical and the practical points of view Moreover, it was demonstrated in the exhibits of the Radio Corporation of America in the annual scientific exhibition Although the subject of the electron microscope is relatively new, contributions have been made to it by a considerable number of scientists

Thousands of persons, amazed at the revelations of microscopes, have wondered why opticians do not continually make them more and more powerful, just as manufacturers produce speedier and speedier automobiles and better and better radio receiving sets They read from time to time of larger and larger telescopes that have power to penetrate farther and farther into the celestial spaces, even to distances that light can traverse only in hundreds of millions of years Then why not, they ask, make microscopes that will enable scientists to explore correspondingly downward toward the infinitesimally small? They hear of micro-organisms, some of them causing diseases of animals and plants, that are beyond the reach of microscopes They learn of organic molecules which are composed of thousands of atoms, yet are also far beyond the range of microscopes They ask why microscopes can not be placed one behind the other, each magnifying the image formed by its predecessor An occasional report of the invention of some new kind of microscope encourages them to believe that finally opticians have stumbled on what should have been obvious all the time

In spite of the never-dying hopes of the uninformed that a super-microscope will be invented, scientists know that there are limitations to the power of microscopes if they depend upon light for their operation For clarity a few words about the meaning of "power" are necessary What the word normally means in this connection is "resolving power," which is, for example, the ability to show equally spaced parallel lines, like those in an engraving, as separate lines Now light is made up of waves whose lengths range from about a forty thousandth of an inch, in the red, to an eighty thousandth of an inch, in the far violet There are infra-red rays having longer waves than the red and ultra-violet rays having shorter waves than the violet



THE ELECTRON MICROSCOPE
OF L MARTON IN BRUSSELS THE INSTRUMENT MEASURES TEN FEET FROM THE COLD CATHODE DISCHARGE TUBE AT THE TOP TO THE PLATE CHAMBER NEAR THE FLOOR

The lengths of these waves are the limiting factor in the resolving power of an optical instrument, however it may be designed and however perfectly it may be made

As a consequence of the wave property of light, an optical image of a point source of light is a little circle surrounded by a series of concentric rings of rapidly decreasing intensity Similarly, an optical image of a line, even infinitely fine, is a narrow streak bordered on each side by parallel streaks of rapidly diminishing intensity It is easy to see that, if several parallel lines, however fine they may be, are so close to each other that the streaks of their optical images merge, they are not resolved into separate lines and that no further magnification will help

The rule is that the resolving power of a perfect microscope is about one half a wave-length Therefore in red light parallel lines can not be separated if they are closer together than about one eighty thousandth of an inch, with violet light the limits are about half as great. Then why not use the shorter wave-lengths of ultra-violet radiation, of course by photographing? It has been done, but the increase in resolving power has been only about twofold. Much shorter wave-lengths can not be used, because the glass in lenses is not transparent to them

Since x-rays pass through glass and even substances opaque to light, why not use them, for their wave-length is of the order of a thousandth that of light, and consequently the resolving power with them would be a thousand times as great? The answer is that though they are analogous to light no suitable means for refracting them to form images has been found As scientists began to despair of the possibility of a supermicroscope a new and entirely different method achieves ap-

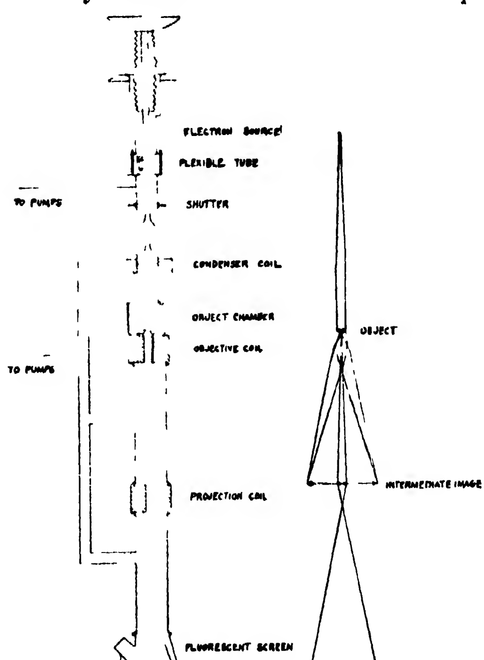


DIAGRAM OF ELECTRON MICROSCOPE
SHOWING PATHS OF THE ELECTRONS FORMING THE ENLARGED ELECTRON IMAGE

proximately equivalent results Instead of light or anything having the essential properties of light, the new method uses electrons which are negatively charged particles Yet, as the French physicist de Broglie found in 1924, there is associated with each electron a sort of wave motion whose wave-lengths are related to its velocity Electrons are not refracted as light waves are, but since they carry electric charges they may be deflected by electric currents and magnetic fields

Now we have in rough outline the underlying principles of the new electron microscope Instead of using electromagnetic (light) waves that are refracted by suitable media (lenses) which change their velocities, the new instrument employs streams of electrons that are deflected at pleasure and brought to a focus by suitable electric and magnetic fields This statement, however, is an over-simplification Refractive media, such as glass, have essentially constant refractive properties throughout The effects of electric and magnetic fields, on the other hand, vary from point to point, often by large amounts Consequently, the relatively simple theory of lens systems can not be employed in the control of the paths of electrons by electric and magnetic fields In addition, there are certain physical laws which express limitations on the way in which the effects of both electric and magnetic fields may vary When all these properties are taken into consideration, it is found that what corresponds to spherical aberration (defects in optical images due to the use of spherical surfaces) can not be completely avoided in electron instruments And since the initial velocities of electrons vary, the defects corresponding to chromatic aberration in ordinary lens systems can not be avoided in electron instruments

On the other hand, electron optics is much more flexible than light optics A lens surface once formed is permanent, electric currents and magnetic fields may be varied almost at will Another important point is that the velocities, and therefore the energies and the effects of electrons, may be increased by electric fields In the case of light optics, however, no increase of light energy in the optical system is possible, on the contrary, much light energy is lost by reflection from surfaces and by absorption The energy of the electrons may finally be transformed, though with some losses, into light, by a fluorescent screen, and therefore the final image is in light, as in the ordinary microscope

A SINGLE BACTERIUM

Staphylococcus aureus (DARK MASS IN CENTER) -ELECTRON OPTICALLY MAGNIFIED 20,400 DIAMETERS, MAGNIFICATION IN PICTURE ABOUT 150,000 DIAMETERS B V BORRIES AND E RUSKA, WHO TOOK THIS PHOTOGRAPH, SUGGEST THAT THE FINE STRUCTURE SURROUNDING THIS PUS-FORMING BACTERIUM IS DUE TO PRODUCTS OF ITS METABOLISM

Fluorescent screens and the fundamentals of the electron microscope are used in the television developments which have been carried out by Dr Zworykin and his associates In television the image of the scene that is to be transmitted is dissected into lines (scanned) which must be repeated a large number of times per second These same principles have re-

A CULTURE OF BACTERIA
Chromobacterium prodigiosum, MAGNIFIED ELECTRON OPTICALLY 750 TIMES (L MARTON).

cently been applied in the development of an electron microscope for the purpose of reducing the slight defects which correspond to chromatic aberration in light microscopes

In attempting to make the principles of these promising developments understandable by those who are not expert in the field, the problems have been somewhat over-simplified and numerous practical difficulties have been ignored The first applications of these new methods have been to investigating the structures of metals and alloys, partly because the obtaining of electrons from such sources is easy and partly because it has been desired to follow the changes in structure to high temperatures. The difficulties in applications in biology are formidable, for everything has to be done in a high vacuum Yet as serious as these and other difficulties are, they have already been largely overcome, particularly through the efforts of Dr L Marton, and photographs of micro-organisms with magnifications far beyond the possibilities with light microscopes have already been obtained Dr Zworykin closed his discussion of the results so far accomplished by various workers, European and American, in this field with these words· "We feel that the present developments in electron optics justify the belief that the day is not far off when electrons will play an essential rôle in biological science, as well as in the study of metals and related disciplines, aiding man to advance further his understanding and his mastery over his environment" Science is reaching as eagerly downward toward infinitesimals as outward toward the infinite

F R MOULTON

SCIENCE DISCOVERS BASIS FOR MAINTAINING MARINE FISHERY RESOURCES

A THEORY which not only explains an important cause of fluctuations in the abundance of fish in the sea but which may also provide the basis for managing high seas fisheries for the benefit of man has recently been advanced by William C. Herrington, in charge of the North Atlantic research staff of the U S Bureau of Fisheries

According to Mr Herrington, too many haddock on the fishing banks off the New England coast are just as undesirable as too few from the standpoint of maintaining maximum production of the fisheries over a long period of years This seemingly paradoxical statement is based on the discovery of a certain optimum level of abundance for the fishery —the level at which the largest numbers of young haddock are produced and survive If the total stock falls below or rises above this level, the fishery fails to receive its normal additions of young in succeeding years.

The importance of this generalization lies in the fact that it provides, for the

first time in the history of marine fishery research either in Europe or America, a basis for a rational exploitation of a marine fishery, an undertaking which has ordinarily been regarded as beyond the control of man

The plan for the management of the haddock fishery rests on a mass of evidence accumulated by Mr Herrington and his staff during an eight-year investigation into the causes of the recent decrease in the availability of haddock to the commercial fishing fleet This decline amounted to approximately 75 per cent between 1927 and 1931 on Georges Bank and South Channel, the principal New England fishing grounds, and threatened the prosperity of the haddock fishery, which during the 20's had expanded to first place in poundage and value among all New England fisheries, relegating the "sacred cod" of almost legendary fame to second place This decline, it was found, was partly the result of the intensive fishery that had developed since 1926 Primarily, however, it was due to the fact that relatively few young haddock were produced from the spawning seasons in 1926, 1927 and 1928, so that in later years there were practically no young haddock coming to commercial size to replace their elders which had been taken by the fishery

How to explain the failure of the spawning seasons of 1926–28 was the principal problem, for in these years spawning adults were abundant Similar failures of young to survive from one or a series of spawning seasons have been noticed in some of the great marine fisheries of Europe

By comparing the average number of three-year-old haddock caught per day by the fishing fleet with the abundance of adults three years earlier, Mr Herrington demonstrated the surprising fact

BIOLOGISTS ABOARD TRAWLERS TAKE A CENSUS OF HADDOCK POPULATION
BY MEASURING THE FISH IN THE CATCH THEY DETERMINE THE RELATIVE NUMBERS OF YOUNG AND OLD FISH MAKING UP THE POPULATION. SUCH A RECORD OVER A PERIOD OF YEARS INDICATES WHETHER OR NOT A FISHERY IS BEING DEPLETED

that survival of young was at its lowest point in years when large fish were extremely numerous In such years the adult haddock were found to spread out over the nursery grounds—areas in which young haddock are ordinarily concentrated—and reduce the numbers of young, presumably by competition for food or directly through cannibalism On the other hand, when the adults were greatly reduced through overfishing or from other causes, there were insufficient spawners and few young were produced Tipping the scales of haddock abundance either way, therefore, reduces the stock available for the commercial fishery

In addition to furnishing a clue to the recent decline, Mr Herrington indicates a remedy: protection of the young fish during the early years of life during which growth rate is greater than natural mortality rate, and maintenance of the spawning stock near the indicated abundance level by regulation of the intensity of commercial fishing Through earlier experiment, Mr Herrington has already devised means of protecting baby haddock from capture in the commercial fishing trawls by developing nets with mesh size adjusted to prevent the taking of any considerable proportion of fish below a given size As soon as analysis of the assembled data has been completed, the Bureau of Fisheries expects to offer definite recommendations to the commercial industry for the management of the haddock fishery

R C.

SCALE FROM A 3-YEAR-OLD HADDOCK

ENLARGED ABOUT 25 TIMES WITH HADDOCK, COD AND SOME OTHER FISH, AGE AND GROWTH RATIO CAN BE DETERMINED FROM THE SCALES, WHICH WHEN EXAMINED UNDER A MICROSCOPE SHOW CONCENTRIC RIDGES SIMILAR TO THE RINGS ON A CROSS SECTION OF A TREE THE SPACING OF THE RINGS INDICATES THE AGE OF THE FISH

MICROPROJECTOR AND CALCULATOR

IN HANDLING SCALES, CELLULOID STRIPS ON WHICH THE SCALES ARE MOUNTED ARE RUN THROUGH A MACHINE WHICH PROJECTS AN ENLARGED IMAGE OF THE SCALE A FEW MOVEMENTS OF A LEVER ARM AND SLIDER SHOW THE AGE OF THE FISH FROM WHICH THE SCALE CAME AND THE SIZE OF THE FISH AT EACH YEAR OF ITS AGE

DOWN INTO THE EARTH

When the Continental Oil Company, a short time ago, reached a depth of 15,004 feet in drilling for oil in California, it had penetrated the skin of the earth more than 2,000 feet deeper than any earlier drill hole. Mining shafts fall far short of these great depths, the deepest one, that of the Robinson Deep gold mine in South Africa, having reached only about 9,000 feet. Soundings have been made in the ocean to depths greater than 25,000 feet, but the water at the bottom differs only slightly from that at the surface. Mt. Everest has been ascended within approximately 1,000 feet of its summit, 29,002 feet above sea level.

The difficulties of drilling to depths greater than 10,000 feet are formidable. Cores of rock are cut out by a rotating drill pipe equipped with a bit at its lower end, after which protecting casings are inserted. In the first 500 feet of the record well the diameter of the casing was 16½ inches, in the next 5,500 feet it was 10¾ inches, and in the remainder it was seven inches. The total weight of the casings was 225 tons.

At the bottom of this deep well the rock pressure, due to the weight of the rock above, is about 15,000 pounds per square inch, and the temperature is 270° F., or nearly 60° above the boiling point of water at sea level atmospheric pressure. It is evident that if there were no other difficulties, the high temperature alone would prevent the sinking of a shaft to such a great depth.

All the rocks in the 15,004 feet penetrated in drilling this deepest well are sedimentary and of modern origin, geologically speaking. The lowest and oldest strata reached are of Miocene Age, dating back only 15 or 20 million years, when the region was beneath a shallow ocean and ancient rivers carried sediments into it and dropped them on its floor. Among these sediments were organic materials which time and pressure and temperature

CALIFORNIA OIL WELL DRILL

and chemical changes gradually transformed into oil which was found in large quantities at a depth of 13,100 feet, the deepest oil-producing strata in the world There are other wells more than 13,000 feet deep in Louisiana and western Texas, some of which produce petroleum

As deep as the California well is, it is only one seventh of one per cent of the distance from the surface to the center of the earth. Therefore, by direct examination only the thinnest skin of the earth is known But by somewhat indirect and almost as certain methods a great deal is known about the interior of the earth even to its center For example, it has been found from the gravitational effects of the earth that its average density is 5 5 times that of water, or about midway between the density of surface rocks and that of steel The earth-tide experiments of Michelson, in 1912 and 1917, proved that the earth is rigid rather than viscous as had previously been supposed. Now investigations of the properties of the seismic waves that pass around and through the earth are leading to definite conclusions about the general structure of its interior, including its several zones and the properties of the materials of which they are composed. This information is of course important in checking theories of the earth's origin and early history

F R M.

AMERICA INHABITED FOR TWENTY-FIVE THOUSAND YEARS

In a small area in northeastern Colorado, several thousand miles from the Aleutian Islands and Bering Straits, across which anthropologists think man first migrated from Asia to the Western Hemisphere, there are numerous stone weapons and implements left by human beings who lived approximately 25,000 years ago These artifacts, left by what is known as Folsom man, are of a general type that have been found over a considerable part of North America

The antiquity of these finds of stone weapons characteristic of Folsom man, and of the bones of long extinct animals associated with them, was determined by Drs Kirk Bryan and Louis L Ray, of Harvard University, from painstaking geological observations and an extraordinarily interesting chain of reasoning The artifacts found in northeastern Colorado, in what is known as the Lindenmeier site, were buried on a gentle slope by glacial debris which Drs Bryan and Ray determined by correlations with other deposits as being of the third Wisconsin glacial substage, and reported to the Milwaukee meeting of the American Association for the Advancement of Science. This period has been correlated by its characteristic year-by-year fluctuations with glaciation in northern Europe, the age of which Antevs has established by counting the yearly deposits from glaciers at favorable locations In this way the history of man in the United States, in which there was no pre-Columbian written history, is being sketched out for 250 centuries

As yet not a great deal is known of Folsom man, though it may be inferred from the fact that he made highly specialized stone weapons and implements, which have been found in thirty states, that his was a virile race The numerous chipped stone articles he left in the Lindenmeier area prove that he had camp sites and villages, and the ashes in these places are clear evidence that he knew how to start fires and use them for warmth and cooking The broken bones of long extinct camels and bisons and other animals which he left among the ashes of his camps are proof of his prowess as a hunter But like the animals he may have exterminated, he has been gathered to his fathers and it is not known whether he has descendants now living

F R M

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THE CHEMICAL INDUSTRY AND THE ECONOMIC SYSTEM

By Dr. HAROLD G MOULTON

PRESIDENT, THE BROOKINGS INSTITUTION

CHEMISTS are of course primarily interested in the development and the successful operation of the chemical industry As a professional student of economics, I am primarily interested in the development and the successful operation of the economic system Chemists are also interested in economics because the growth of the chemical industry depends upon the successful operation of the complex economic system of which it is an integral part Similarly, economists are interested in the organization and conduct of the chemical industry because it is a highly important division of the economic system.

FUNDAMENTAL FACTORS AND INTERRELATIONSHIPS

As a background for this discussion, it will be useful first to orient our thinking in very fundamental terms. Economic progress depends basically upon the combined influences of the following factors. Natural and human resources, scientific discoveries; inventions; engineering applications, business organization and management; the economic system; and the governmental system Scientists, inventors, engineers, business managers and professional students of economics and government are, in final analysis, cooperating in a common objective—that of increasing the capacity of mankind to satisfy their wants

Each of these groups naturally thinks of itself as of primary importance, but the sanest conception is that every one of them is essential Scientific discoveries would not yield practical results if we did not have invention; patented technological apparatus and devices would be impotent were it not for engineering applications to productive processes; engineering can function only in conjunction with a business enterprise which appraises favorably the feasibility of the development in relation to other factors of production and the potentialities of profit and loss The individual business enterprise in turn will be thwarted if the economic system is defective; and the functioning of the economic system is dependent upon the character of the governmental organization which has been developed

As a result of a combination of developments, which can not here be summarized, these various elements in the situation came to work together so effectively as to give us a century or more of phenomenal progress In the course of the nineteenth century, the population of Great Britain, for example, increased from 10½ millions to 37 millions, while at the same time the standards of living rose approximately

four-fold In the United States between 1850 and 1930 the population increased from 23 millions to 123 millions, meanwhile, the per capita production rose nearly three-fold Scientific discoveries, inventions, engineering, effective business management and a successfully functioning economic and governmental system combined to produce a truly golden age.

In recent years, however, men everywhere have been profoundly concerned over the future For a combination of reasons we have had for a decade a cessation of economic advancement, indeed, in many places there has been economic retrogression This arresting, not to say ominous, development compels us to reexamine fundamentals Scientists feel a sense of frustration, inventors secure patents which run to waste for lack of commercial development, opportunities for engineers are restricted, business is physically depressed, and business men are spiritually demoralized, economists are perplexed, and government officials are both confused and apprehensive

The Operation of the Economic System

Where is the source of difficulty in the complex process to which we have referred? Is there something inherently defective in the economic system, or has it merely been operated badly? It must be borne in mind that under a system of individual business enterprise the economic system is operated by business managers in quest of profit. I wish, therefore, to review the basic principles involved and the procedures which must be followed if the economic system is to perform satisfactorily its essential function of producing and distributing an abundance of goods and services The incentives for business enterprise and the mechanisms by which the system of private business enterprise is supposed to be operated have often been expounded by both professional economists and business leaders.

First, it is contended that each business manager naturally stands to gain by increasing general over-all efficiency and thereby reducing costs of production He may accomplish this result by the construction of a larger and more efficient plant, by the installation of better equipment, by the introduction of superior internal management, by improved methods of marketing, by integrating various stages in the productive process, or by a combination of various methods

Second, having reduced costs of production, the business manager is in a position to increase his profits in one or the other of two ways He may continue to sell at the same price as before, enjoying the advantage of a wider margin between cost and selling price, or he may expand the volume of his business by means of price reductions It is reasoned that since the increase in efficiency which is responsible for the reduction in costs commonly involves an expansion of productive capacity, and since the maximum economies can be obtained when operating at full capacity, the greatest profits will result if sales are expanded by means of a reduction of prices In short, increased efficiency makes possible lower prices, and the profit incentive leads to actual reductions of prices

Third, the process naturally involves the continuous elimination of obsolescent or otherwise inefficient equipment and establishments The industrially fit, as gauged by ability to sell at a minimum price, alone survive, moreover, the efficient of to-day often become the inefficient of to-morrow A particular business man, firm or corporation may survive over a long period of years, but only if the production methods employed keep always abreast of changing times

It is clear that with a system thus operating the standards of living would steadily rise. The progressive reduction of prices as efficiency increases would, of course, constantly increase the purchasing power of the masses, giving them an

increasing volume of goods for the same money.

It should be carefully noted that this theory of progress implies that the reduction in money costs must result from increased efficiency rather than from a mere reduction in money wage rates A reduction in wage rates may indeed lower money costs and prices, but since such a reduction increases neither efficiency nor the purchasing power of the masses, there is no resulting economic advancement.

In order to reveal more distinctly what is involved in raising living standards in a *pecuniary* society, I state explicitly two principles as follows.

First, *the process of raising the standard of living of wage-earners necessarily involves increasing the spread between wage rates and prices.* That is, a wage-earner can increase the volume of his purchases from year to year only if wage rates are increased relatively to the prices of the commodities which he buys If he gets more dollars and prices remain unchanged, his purchasing power is expanded, if he gets the same number of dollars and prices decline, his purchasing power is expanded. There are, of course, other possible combinations of changes in wages and prices, but the purchasing power can not be expanded unless the spread between wages and prices is increased

Second, *an increasing spread between wage rates and prices depends fundamentally upon increasing the efficiency of production.* While minor and temporary increases in wages may sometimes be achieved by trenching upon profits, a progressive increase in the wage-price ratio depends directly upon the acceleration of technical advancement, improved management, increased labor efficiency, etc Any practices or policies that tend to work in this direction are economically sound; those which work in the opposite direction are economically unsound

The Role of Chemistry

It is superfluous for me to attempt to instruct chemists about the significance of chemistry and the chemical industry. But since many chemists are specialists, deeply immersed in particular aspects or divisions of chemistry, it may be useful even for them if I summarize some of the development which has occurred in the industry as a whole during the past fifteen years I shall not, of course, presume to say anything about the significance of individual chemical products or particular divisions of the industry, my comments will relate simply to the industry as a whole

The fundamental significance of the chemical industry lies in its permeating influence Chemistry is not merely a new industry which has added an important series of new products for human consumption. It is an industry, the achievements of which profoundly affect the productivity of many other industries; indeed, its influence ramifies throughout the economic system Chemistry is *creative,* to use Slosson's phrase, not only in the sense that it involves both *analysis* and *synthesis,* but also in that it yields practical results of great utility.

Its primary *creativeness* lies in its fructifying influence Chemistry cuts across and underlies so many productive processes that the term *fundamental* is truly descriptive of its significance As the *science of the transformation of matter,* it not only relates to nearly every aspect of our lives from birth to death, but, as Stieglitz has written, its

> wizardry permeates the whole life of the nation as a vitalizing, protective and constructive agent very much in the same way as our blood, coursing through our veins and arteries, carries the constructive, defensive and life-bringing materials to every organ in the body . . . It makes possible scientific control of such widely divergent national industries as agriculture and steel manufacturing It governs the transformation of the salts, minerals and humus of our fields and the components of the air into corn,

wheat, cotton, and the innumerable other products of the soil; it governs no less the transformation of crude ores into steel and alloys, which, with the cunning born of chemical knowledge, may be given practically any conceivable quality of hardness, elasticity, toughness or strength And exactly the same thing may be said of the hundreds of national activities that lie between the two extremes of agriculture and steel manufacture!

From the strict economic point of view the basic significance of chemistry is found not only in the wealth of new and important products that it has created, but also in the way in which it has affected efficiency and costs of production in the varied industrial fields to which it contributes By developing new methods which improve the efficiency of production, as well as the quality of products, chemistry is cumulative in its influence While we can not trace these effects in detail, it is possible to measure the achievements of the industry by analyzing its growth and its contributions to society as a whole in terms of available data respecting productivity in relation to prices, wages and profits

During the course of the past fifteen years the prices of chemical products as a group have declined about 16 per cent Drugs and pharmaceuticals as a group show a substantially greater decline, amounting to about 22 per cent., while the prices of fertilizer materials decreased as much as 30 per cent These declines may be compared with a decrease in the average prices of manufactured products as a whole of about 12 per cent , and with a decrease in the average prices of all commodities, including agricultural and raw material products, of about 19 per cent Thus, viewed from the standpoint of price reductions, the showing of the chemical industry is distinctly better than the average of American industry

We may examine next the wages paid in the chemical industry as compared with manufacturing as a whole Between 1923 and 1938 *total* wage disbursements in the chemical industry increased approximately 30 per cent ; *hourly* wages increased 31 per cent. Meanwhile, in manufacturing as a whole total wage disbursements declined by approximately 10 per cent, though hourly wages increased by about 15 per cent

Employment in the chemical industry has expanded materially during the course of the past fifteen years Comparing the three years 1923 to 1925 with the three years 1936 to 1938, we find that employment has increased nearly 25 per cent This is in sharp contrast with the trend of manufacturing industry as a whole, where the total number employed has declined by approximately 1 per cent These employment figures indicate both that the chemical industry has been undergoing rapid growth and also that the improvements in productive efficiency which have occurred have not been at the expense of labor As we have seen, the number of workers employed has increased materially, and wages have risen substantially At the same time, in so far as workers in the chemical industry are consumers of chemical products, they have benefitted by products of improved quality sold on a gradually declining price basis

These developments have of course been made possible by a constantly increasing volume of investment in the industry and by an increased productivity resulting from technological developments In the past 15 years the fixed capital investment of the four largest chemical companies has nearly doubled As an accompaniment to this expanding investment, together with improvements in management, productivity has greatly increased The output per man hour has in fact increased by approximately 75 per cent

The return to stock owners has been unusually satisfactory. During the past 15 years dividends have ranged from 5.6 to 13 5 per cent on the book value of

the stockholders' investment. Payments were maintained at a high level during the depression years

It is of interest that the investment in the chemical industries of the United States now exceeds 4 billion dollars, and is equal to about 7 per cent of the investment in all manufacturing enterprises Measured by the value of the sales, the chemical industry now ranks third in the United States, being exceeded only by metals and metal products and food and kindred products, which represent broad industrial classifications

The achievements of the chemical industry in recent years may be summarized as follows·

Expanding capital investment and increasing efficiency have made possible a reduction of prices, an increase of wages, both hourly and aggregate, an increase of employment, and a comparatively high level of profits At the same time there has been a great improvement in the quality and variety of products, some of which minister directly to the satisfaction of human wants and others of which contribute to increasing efficiency in a wide range of other industries

Requirements for the Future

At the present time, as every one is aware, grave fears are entertained by many with respect to the future of the economic system in this country In recent years the view has been widespread that we have had so much scientific and technological advancement that we are menaced with over-production and that in consequence we must expect the rate of industrial progress to be severely curtailed

It is of interest to note for purposes of comparison that fifty years ago similar fears were expressed with respect to a great increase in productive capacity In the middle eighties an eminent economic writer, David A Wells, attributed the great depressions of trade in the seventies and eighties to the fact that "the supply of the great articles and instrumentalities of the world's use and commerce has increased, during the last ten or fifteen years, in a far greater ratio than the contemporaneous increase in the world's population or of its immediate consuming capacity " Carroll D Wright, in an official government report in the late eighties, expressed a similar concern over the lack of investment opportunities and employment possibilities He wrote

> The rapid development and adaptation of machinery have brought what is commonly called "over production " The nations of the world have overstocked themselves with machinery and manufacturing plants far in excess of the wants of production The day of large profits is probably past

Nevertheless, in the following forty years we experienced the greatest period of technological progress and industrial expansion in our history There is no more reason for assuming in the late 1930's that we have reached the end of industrial progress than there was for the same assumption in the late 1880's The income of the American people is still far below the requirements for satisfactory standards of living In 1929, the year of our greatest production, the total national income was about 81 billion dollars, or the equivalent of about $660 per capita—$2,600 per family Twelve million families, or 42 per cent of the total number, had incomes of less than $1,500, and 60 per cent of the families had incomes of less than $2,000 At 1929 prices, a family income of $2,000 was sufficient to supply little more than the basic necessities required for health and efficiency, generally speaking, it provided no margin for comforts and luxuries of life Budgetary studies indicate that the provision of "reasonable standards of living" would require an income nearly double that received by the masses of the American people in the year of our greatest production [1]

[1] "America's Capacity to Consume," The Brookings Institution

In the years that have elapsed since 1929, however, there has been an actual curtailment of national productive capacity, while at the same time we have had a further increase of population of more than 7 per cent. Per capita production in 1937—the best year of the recent recovery movement—was only about 85 per cent as great as in 1929. The available income was only a little over $500 per capita. So long as the great masses of our people have vast unfulfilled desires we should obviously continue to increase productive efficiency in order to raise the standards of living

Is There Room for Expansion?

We may also consider still another argument that has been advanced in support of the view that the era of industrial expansion has ended and that improvements in living conditions in the future must necessarily be at a very much slower rate than in the past A number of factors and considerations lie behind this conclusion, the principal ones of which are The disappearance of the frontier, the substantial completion of the building of our great industries, with no significant new ones in sight; and the declining rate of population growth, forecasting a stationary population in the not distant future The severe and persistent character of the great depression which began in 1929 is also regarded as evidence that fundamental changes in the American economic scene have already occurred This conclusion is perhaps a natural outgrowth of the prevailing character of American economic development over the course of the past century.

We had vast unsettled areas and unexploited resources, we had a rapidly expanding population, resulting both from a high birth rate and large immigration, and we built a never-ending series of new industries—railroads, public utilities and manufacturing enterprises of every description In the light of this history and of the recent period of stagnation, it is easy to understand how it might appear on first thought that our future, so to speak, lies behind us

A factor of vital importance has, however, been overlooked in this line of reasoning Before looking forward, let us look backward for a moment and examine the sources of expansion in the past. Economic activity—the use of our labor power and our capital equipment—has always been directed to a double purpose. the production of goods to care for the needs of increasing numbers of people, and the production of increasing quantities of goods to meet the growing demands of the existing population. Stating the matter in other terms, we not only seek to produce enough to provide our children with necessaries, but we hope to enable them, as well as ourselves, to enjoy higher standards of living than were attained by our predecessors

We may translate these general statements into specific terms by reference again to what actually occurred in the great era of expansion from 1900 to 1929 We did, it is true, devote our energies to the production of primary goods and services for a steadily expanding total population, but at the same time we were constantly producing more for the already existing population In the course of this thirty-year period as a whole, *per capita* income rose almost 40 per cent

Is it not obvious that a cessation of population growth does not render it necessary for us to refrain henceforth from producing more and yet more for the existing population? Are not the unfilled wants and unsatisfied desires of the present 130 millions of people just as real a source of potential demand as the elemental needs of those who may be born in the years ahead? The *character* of our productive output might differ in considerable degree, but the

total output need not be affected—that is, not until our desires are fully satiated. Studies indicate that we need have no concern on this score until the national income is at least three times its present level. We have been accustomed to thinking of expansion in terms of frontiers, geographic areas and numbers of people—that is, in *extensive* rather than *intensive* terms Hence we are prone to overlook the vast potential markets that may be opened on the intensive frontier of development.

If we are to expand this frontier and realize progressively higher standards of living—and, in the process, furnish increasing employment for both labor and capital—we must—as I have already indicated—operate the economic system on sound principles I close with a re-emphasis of the underlying requirements for continued progress

There must be constantly increasing efficiency in production on the part of both labor and capital Only by everlastingly improving technical processes and lowering the costs of production can we obtain progressively higher standards of living To try to accomplish this result in any other way means simply tugging in vain at our collective boot straps

As efficiency is increased, the benefits must be broadly disseminated among the masses by means of high wages, low prices or a combination thereof This is essential for a double reason·

First, it is a fundamental requirement for social and political stability and the well-rounded growth of a democracy. It is doubtful indeed if any economic or political system can permanently maintain itself unless it does maintain the goal of the greatest good for the greatest number.

Second, a broad dissemination of the benefits of technical progress is necessary to provide the market demands for an expanding industry Under our capitalistic system we produce to sell goods in the market If we increase capacity to produce without correspondingly increasing the capacity of the masses to purchase, we simply reach an impasse Production schedules have to be restrained, with an accompanying retardation of the rate of economic progress

Industrial growth, development, progress, require the expansion of consuming power step by step with an expansion of producing power To put the matter in very simple terms· Healthy growth in the economic organism, like healthy growth in any other organism, must proceed from the deepest and broadest possible rootage It must rest on the expanding well-being of the entire population.

THE FOURTH KINGDOM

By Dr. E. B. BENGER

GENERAL ASSISTANT CHEMICAL DIRECTOR, E I. DU PONT DE NEMOURS & COMPANY

AT the dawn of history, we find man employing for all his needs materials as supplied by nature Man secured food from plants and animals, clothing came from the same sources, and shelter was commonly afforded by a convenient cave For thousands of years, nature, almost unaided, supplied man's primary needs

Little by little, man learned to modify natural products He chipped sharp instruments and deadly weapons from rock, he fashioned knives from naturally occurring metals, such as copper, he learned to weave rude fabrics Probably through accident, glasses and metallic iron were found in the ashes of fires Such discoveries perhaps marked the beginning of a new era But progress was painfully slow At times, nature seemed niggardly indeed in supplying the necessary materials for life and safety Famine was not uncommon, pestilence and disease often took thousands of lives As man became better organized in social and political units, the deprivations, sufferings and the need for better things, and more of them, led to taking these things from others by force

The acquisition of territory by force and by threat of force is not unusual in the world history In fact, ever since the days of Alexander the Great, kings and emperors have expanded their empires through military conquest This has, of course, chiefly been for the purpose of gaining additional materials—gold, cattle or grain We have seen a number of such conquests even in the last few years Even we, here in America, may have been guilty of acquiring valuable property through military aggression

But America has acquired peaceful habits This has come about, partly at least, from the fact that we have not been forced to provide our needs by conquest. America has obtained products of more enduring value than were ever won by Alexander or Cortez or Pizarro, and without the use of swords, guns or poison gas These products, which have increased our national wealth by untold millions, have become available through the peaceful conquest of matter This conquest has been without wide-spread suffering or death, it has, on the contrary, created new industries, opened up millions of jobs, and made life happier and safer for all

We were taught in school that there are three kingdoms of matter—the animal, the vegetable and the mineral More recently, we have come to look upon the substances from the three natural kingdoms as raw materials rather than as finished products We are still largely dependent upon animals and vegetables for food, and from the earth we still take metals, coal and other valuable minerals Many of these things are still employed more or less as nature provides them, but this is only because we have not yet been able to improve upon many of nature's products We can not now offer more tender and juicy synthetic beefsteaks or a more beautiful man-made rose!

The fourth kingdom, of which I shall speak to-day, has, however, become firmly established, and the products of the fourth kingdom, made in turn entirely from the animal, vegetable and mineral kingdoms, now supplement the products from the three original kingdoms themselves

The conquest of the fourth kingdom was slow in getting under way It is far from complete now, after a century of incessant and increasing attempt. Possibly we can say that inroads on the new kingdom began in 1828, when Wohler synthesized for the first time an organic material occurring in nature, namely, urea Until that time it was believed impossible ever to produce artificially the products produced by animal or vegetable life Wohler's disproof of this theory may be taken as the first stroke in the conquest of the fourth kingdom

About thirty years after Wohler, a young British chemist, Perkin, undertook to synthesize quinine He failed, but, as is often the case in an experimental work, achieved a result of greater importance than the one he sought He didn't get quinine, but he made the first synthetic coal-tar dye We can still get natural quinine in quantity, but we wouldn't want to do without the thousands of synthetic colors which brighten our lives

With these simple beginnings, it became apparent that nature's products could be employed in the construction of entirely new compositions, which in turn could be used in countless ways The conquest of the new kingdom, the chemical kingdom, then was undertaken more earnestly To-day, the conquest is carried on by an army of 32,000 research workers in over 1,700 laboratories in the United States The maintenance of the army costs $250,000,000 a year, which, after all, represents a very cheap campaign, in fact, not as much as we spend on cosmetics

I shall now mention some of the materials which we have acquired by the conquest of this new kingdom

The textile industry is a very old one, dating back to the earliest records of man For four thousand years no new textile fiber appeared You are familiar with the amazing development of the synthetic yarn, rayon, which in the last two or three decades has sprung into being and grown so fast that now seven times as much rayon as silk is used in America This rayon, made from the cellulose of cotton and wood, has been dependent upon the vegetable kingdom for its basic material But recently, you have heard that an entirely new fiber, dependent only upon the mineral kingdom, has been made I refer to nylon, a name coined for a family of new synthetic compounds Nylon has a structure somewhat like that of proteins, and from it can be spun filaments of extreme fineness, stronger and more elastic than any of the natural fibers Probably the most important of the early uses for nylon will be in women's fine hosiery It is also hoped, however, that dress goods, gloves, draperies and upholstery may be produced from this new synthetic product

Incidentally, from nylon we already have available the new "Exton" bristle for use in toothbrushes These bristles are more durable, soften less when wet, and do not shed From bristle-like materials we also have fishing leaders and fishing lines

I mentioned Perkin's discovery of mauve Previously the textile industry was entirely dependent upon vegetable and animal colors These natural dyes were limited in number and in many cases the fabrics colored with them were dull and faded when washed or exposed to light Furthermore, many of the natural dyestuffs were very expensive The Tyrian purple of Biblical times was obtained from a shell-fish found in the Mediterranean, and purple woolen fabrics were so costly that they could only be bought by kings and nobility, hence the term "royal purple." To-day, the chemist makes a complete rainbow of bright, fast colors from coal tar, far exceeding in brilliance and permanence the royal purple of antiquity, and at a cost so low that colors are abundant in even the poorest of our homes

The modern textile industry could not exist without the dyestuffs and fibers of the fourth kingdom.

Many accessory textile chemicals have also been made synthetically. Thus fabrics are made more resistant to creasing and wrinkling and more water-repellent and freer from spotting by rain because of chemical treatments. We also have the new "soapless soaps," which work as well in hard water as in soft water, and wetting agents to speed up the bleaching and dyeing operations—agents so potent that water to which a small amount has been added will actually cause a duck to sink We have effective moth-repellents, mildew inhibitors and a new chemical which renders fabrics flameproof

From the mineral kingdom comes the coal, limestone and salt needed for the manufacture of another valuable synthetic which, strangely enough, closely resembles in certain respects an important product of the vegetable kingdom—rubber I have reference to neoprene, the man-made rubber-like material, which, although similar to natural rubber in elasticity, toughness and strength, is wholly different in chemical resistance Whereas rubber is attacked and destroyed by oils and greases, neoprene is resistant to them It is because of this that neoprene, although now selling at about four times the price of rubber, is, nevertheless, finding an increasing outlet in the manufacture of such items as hose for gasoline pumps, industrial and household gloves, printing rollers, belts for conveying oily materials and numerous other purposes where rubber is inadequate For certain of these purposes, neoprene outlasts rubber ten to twelve times or even more

Among the hundreds of applications for this man-made rubber are some 50 uses in the automobile industry alone, including insulation for ignition cable and horn wire, shock absorber gaskets, thermostat diaphragms and water-pump seals

Among the numerous products of the new chemical kingdom, probably none finds wider application than the man-made plastics Supplementing and displacing such natural products as wood, metals, rubber, shellac, ivory, tortoise shell, jade and amber, the synthetic plastics find application in the manufacture of literally thousands of articles—motion picture film, automobile accessories, radio cabinets, windshields for airplanes, electrical appliances, lighting equipment, plates for false teeth, toiletware, ash trays, buttons and buckles, scuffless shoe heels and costume jewelry

Laminated plastics, made by combining a number of sheets of plastic-impregnated cloth, paper or wood under high pressure at an elevated temperature, possess great strength, and are accordingly used in making such articles as wall board, instrument panels and gear wheels—supplementing or wholly replacing such natural materials as wood, metals and slate In the not distant future, these laminated plastics may play an important part in the construction of automobiles and airplanes

One of the newest plastics is "Lucite" methyl methacrylate plastic, made from coal, air and water Because of its toughness and transparency, this new material is finding application for a variety of uses, both decorative and industrial. For example, the reflector buttons along Route 16 between Detroit and Lansing, Mich, are made of "Lucite," and during the first three months following installation of these reflectors there were 79 per cent fewer night accidents than for the corresponding period before they were installed Their effectiveness is shown by the fact that during the same period daytime accidents declined only 37 5 per cent

A very recent addition to the plastics family is "Butacite" polyvinyl acetal plastic, used as the interliner in laminated glass Because of its strength, toughness and flexibility, particularly at

low temperatures, "Butacite" makes possible the safest safety-glass ever made. At the Franklin Institute in Philadelphia a nine-ounce steel ball was dropped 85 feet onto a sheet of this new safety glass The glass was, of course, cracked, but it did not shatter, and observers seated within four feet were in no danger from flying splinters

Camphor is an essential part of the nitrocellulose or celluloid-type plastics used in making motion picture film and dozens of other products For many years, this material came from the camphor trees of Formosa, an island in the Pacific owned by Japan The Japanese controlled the world market for camphor and, with it, the price. But in recent years chemists have worked out a process by which turpentine from our southern pine trees is converted into camphor that is chemically identical with that obtained from camphor trees of faraway Formosa To-day the du Pont Company is producing a substantial part of our total domestic consumption, and in an emergency additional plant capacity could be provided to take care of our entire domestic requirements In 1918, the price of imported camphor reached $3 75 a pound, to-day the synthetic product sells for around 35 cents a pound Quite a difference!

For nitric acid, nitrogenous fertilizers and other forms of combined nitrogen so essential to industry and agriculture, man was formerly dependent largely upon natural deposits of sodium nitrate in Chile These materials are now supplied from the fourth kingdom The chemist takes nitrogen from the air and hydrogen from water and, at an elevated temperature and tremendous pressure, forces these two gases to combine in the form of ammonia From this ammonia is made the nitric acid needed in the manufacture of nitrocellulose for plastics, lacquers. smokeless powder and "Fabrikoid" pyroxylin-coated fabrics Nitric acid is used also in making fertilizer chemicals such as sodium nitrate.

Another fertilizer chemical is urea, a product once obtained only from animal secretions, but now made by du Pont from coal, air and water in tremendous quantities

In addition to its use as a fertilizer chemical, urea finds application in the manufacture of an important type of plastic which is widely used in making light fixtures, unbreakable tableware and housings for counter scales Urea is also finding an increasing outlet in the field of medicine, to replace the maggots once used in the healing of certain stubborn infections, particularly of the bone

Formaldehyde, made from methyl alcohol, is another important chemical used in the manufacture of plastics, in combination with urea, casein from milk or phenol from coal tar Formerly methyl alcohol, known more commonly as wood alcohol, was obtained by the dry distillation of wood To-day, in a plant at Belle, W Va, the methyl alcohol used in making formaldehyde, and for a wide variety of other industrial purposes, is produced by synthesis, again starting with coal, air and water

The farmer and fruit grower turn to the new kingdom of synthetics for improved weapons with which to combat the plant diseases and hungry insects which are responsible for losses estimated at more than three billion dollars a year. From the research laboratory have come improved insecticides, such as the new "Loro" insecticide—materials less toxic to humans than nicotine, and which unlike rotenone and pyrethrum, are based on domestic raw materials

Whereas man formerly went directly to the vegetable and animal kingdoms for perfumes and flavors, to-day nature's products are supplemented by synthetics from a variety of sources, including malodorous coal tar And certain odors are to be had only as synthetics—that of the

lilac, for example, which is so delicate as to be destroyed when an attempt is made to take it from the flower

The characteristic ingredient of musk, obtained from deer that live in the lofty mountains of Tibet, would be worth some $40,000 a pound if it could be had in a perfectly pure state But the new chemical kingdom has recently provided "Astrotone" synthetic musk, substantially identical with the characteristic ingredient of natural musk, at only a fraction of the cost

And last, but not least, the medical profession would be well-nigh lost without the materials of the fourth kingdom The physician and surgeon turn daily to the realm of synthetics for chemicals that nature either failed to make or to provide in quantities sufficient for our needs—anesthetics which are not habit-forming, chemicals which may safely be used for allaying fever and pain, vitamins to supplement our diet, hormones for the correction of various mental and physical disorders and drugs which are specifics for certain diseases

Within recent years, the chemist has synthesized several of the vitamins—those materials occurring naturally in small amounts in certain foodstuffs, which are so essential in warding off rickets, pellagra and other deficiency diseases It has recently been found, for example, that synthetic ascorbic acid is identical with Vitamin C found in fresh fruits and vegetables, a deficiency of which leads to scurvy, fragility of the bones and loosening and decay of the teeth—ills once common among sailors on long voyages

Members of a late Mount Everest expedition took along a supply of synthetic Vitamin C instead of the large quantities of fresh fruits and vegetables which would have been necessary to supply them with an adequate amount of this highly essential vitamin

The research chemist has established the constitution of, and synthesized, certain of the hormones, those little-understood secretions of the ductless glands, which in some mysterious way regulate the functioning of our bodies and minds Research is constantly being directed to a better understanding of these complex, powerful chemical substances, an excess or shortage of which may determine whether we are giants or midgets, brave or cowardly, feeble-minded or possessed of a vigorous intellect

Even the degree of one's masculinity or femininity now appears to be a matter of hormones, and recent research has shown that by the injection of a small amount of the proper sex hormone a tom-cat can be made to mother a litter of kittens, and by similar treatment the gallant and haughty barn-yard rooster is transformed into the maternal-like guardian of a flock of biddies What the future is for sex hormones no one can say with certainty, but there are indications that timid souls such as Caspar Milquetoast may be transformed overnight into Robin Hoods

Since the advent of "Salvarsan" thirty years ago for the cure of syphilis, no synthetic chemical has met with so welcome a reception, or shown greater promise, than sulfanilamide Although introduced into the United States only a few years ago, this new healing agent has already saved the lives of thousands suffering from "blood poisoning," peritonitis, streptococcic sore throat, childbirth fever and other dangerous maladies due to streptococcic infection

And during the past few months a related synthetic chemical, sulfapyridine, has shown great promise in the treatment of various types of pneumonia, which claims each year a toll of some 100,000 lives in the United States

Thus we see that the products of the new chemical kingdom minister unto our needs on every hand Without them,

modern industry would be paralyzed, much of beauty would be gone from our lives, and living itself would be more hazardous

Consider, for a moment, the field of transportation To this all-important field the fourth kingdom supplies steels and other alloys without which there would be no automobiles, airplanes or modern trains This new kingdom provides the blasting agents needed for mining the metals from which these alloys are made It supplies the quick-drying finishes to facilitate mass production, tire fabrics of rayon which add greatly to the life of truck and bus tires on long, non-stop runs, improved fuels which made possible the modern high-compression motor, extreme-pressure lubricants essential to the hypoid gear, lead tetraethyl to prevent knocking, antioxidants for gasoline to inhibit the formation of gums which would clog up the motor and fuel lines

From this new kingdom of synthetics come chemicals which speed the vulcanization of tires, and other chemicals which retard their deterioration by sunlight and air, the man-made rubber which serves where the natural product is unsuited, chemicals for plating, and plastics for safety glass and accessories

And the end is not yet in sight Where shall we turn to find the new materials demanded by an industrial and social order whose very watchword is progress?

In the field of transportation, where shall we turn to find new materials capable of standing the strain of ever-increasing speed by land, water and air?

Where will the farmer turn for still better fertilizer materials and insecticides?

Where will the medical profession turn to find a cure for cancer and like "incurable" diseases?

Where but to the laboratories of fundamental and applied research?

The unsolved problems of industry and agriculture, and the physical and mental ills for which there is as yet no cure, stand as a challenge to the research workers of the fourth kingdom, whose motto is, "We serve "

SCIENCE AND THE WORLD OF TO-MORROW

By Dr. ROBERT A. MILLIKAN

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EVEN though "prophecy is the most gratuitous form of mistake," and even though there is obviously the possibility that something so completely foreign to my thinking may happen as to make any prognosis that I may hazard now look ridiculous in the years to come, yet I am going to be foolish and rash enough to forecast that, barring the return of the dark ages through the triumph the world over of tyranny over freedom, of the spirit of world conquest over the spirit of reason and peaceful change, life in America fifty or a hundred years hence will not differ nearly as much from the life of to-day as the life of to-day differs from that of a century or even a half century ago The processes and techniques that have been responsible for the enormous changes of the last century will continue to improve our economic and social well-being, but the main changes will come from a more general understanding by the voting public of the nature of these processes and a more intelligent use of them This will mean the gradual elimination of the effort to violate natural and social laws or, arithmetically stated, to make two plus two equal six, as we have been so ignorantly and so disastrously trying to do in much of our social floundering of recent years

So long as one is considering only the physical or biological bases of change the informed and competent scientist has some reason for confidence in his analysis as to the general direction which progress can and must take He at least knows a great many sorts of things that will *not* happen, and these are in the main the very things that the uninformed dreamers and wishful thinkers—the emotional pseudo-reformers, not the real ones—hope and expect to see happen. Thus, we shall never be able to transform the energy released in the burning of coal or in the absorption of the sun's rays directly and completely into electrical energy Indeed, we shall never be able to go very much farther in this direction than we have already gone.

To-day the most efficient internal combustion engines transform into work 35 per cent of the heat energy released in the burning of the fuel, and it is safe to predict that in continuous operation we shall never be able to make very great advances beyond this limit By that I do not mean that through improvements in details efficiencies in the neighborhood of say 50 per cent are completely out of the question But in any case, the so-called second law of thermodynamics, which has now taken its place as a part of the core of established knowledge in physics, stands in the way of the realization of the dreams of the multitude of inventors and magicians who still want to transform the sun's heat rays directly and completely into work Though the knowlege that it can not be done is less than a hundred years old, it is about as firmly established as is the law of gravitation

I have chosen the foregoing illustration because it lies at the very base of any correct analysis of what science has done and of what it is capable of doing in the future in bettering man's lot on earth. Let us look first at what it *has* done, for this will enable us to understand better what it can do When in 1825 my grandfather loaded into a covered wagon his young wife, his Lares and Penates and

all his worldly goods, and trekked west from Stockbridge, Mass, first to the Western Reserve in Ohio, and again in 1838 to the banks of the Rock River in western Illinois, the conditions of that migration, the motives prompting it, the mode of travel of the emigrants, their various ways of meeting their needs and solving their problems, their whole outlook upon life, were extraordinarily like those which existed four thousand years earlier when Abraham trekked westward from Ur of the Chaldees In a word, the changes that have occurred within the past hundred years not only in the external conditions under which the average man, at least in this western world, passes his life on earth, but in his superstitions, such as the taboo on the number thirteen or on Friday sailings (why, my own grandmother carried a dried potato in her pocket to keep off rheumatism) in his fundamental beliefs, in his philosophy, in his conception of religion, in his whole world outlook, are probably greater than those that occurred during the preceding four thousand years all put together Life seems to remain static for thousands of years and then to shoot forward with amazing speed The last century has been one of those periods of extraordinary change, the most amazing in human history

If, then, you ask me to put into one sentence the cause of that recent rapid and enormous change I should reply "It is found in the discovery and utilization of the means by which heat energy can be made to do man's work for him" The key to the whole development is found in the use of power machines, and it is a most significant statistical fact that the standard of living in the various countries of the world follows closely the order in which so-called labor-saving devices have been most widely put into use. In other words, the average man has to-day more of goods and services to consume in about the proportion in which he has been able to produce more of goods and services through the aid of the power machines which have been put into his hands In this country there is now expended about 13 5 horsepower hours per day per capita—the equivalent of 100 human slaves for each of us, in England the figure is 6 7, in Germany 6 0, in France 4 5, in Japan 1 8, in Russia 0 9, in China 0 5 [1] In the last analysis, this use of power is why our most important social changes have come about This is why *we* no longer drive our ships with human slaves chained to the oars as did the Romans and the Greeks This is why we no longer enslave whole peoples, as did the Pharaohs, for building our public structures and lash them to their tasks This is why ten times as many boys and girls are in the high school to-day in the United States as were there in 1890—more than five million now, half a million then This is why we have now an eight-hour day instead of, as then, a ten, a twelve—or sometimes a fourteen-hour day This is why we have on the average an automobile for every family in the country This is why the lowest class of male labor, *i e*, unskilled labor, gets nearly twice as much in real wages in the United States as in England, three times as much as in Germany or France, and thirteen times as much as in Russia, and this is why the most abused class of labor in the world, domestic service, is even better off relatively in this country though completely unorganized, *i e*, through the unhampered operation of economic laws, than is any other class of labor, skilled or unskilled

Do not think that these are the one-sided pronouncements merely of an enthusiastic scientist Any one can check them who will begin to study them Listen to President Karl Compton's

[1] These figures are substantially as given in *Am. Economic Review*, 1933, p 58, Read, and in "Toward Civilization," Hirshfeld, 1929.

formulation of the results of his similar historical studies He says:[2]

From the days of the cave man, all through history up to the modern era of science, there were only two primitive recipes for securing the materials desired for the more abundant life One was to work hard and long in order to produce more, and the other was to take the good things of life from some one else, by theft, conquest, taxation or exploitation

To get the good things of life by taking them from others is a primitive instinct, undoubtedly developed by the age-old struggle for existence We have all seen monkeys, or seagulls, or wolves, or pigs snatching food from each other, fighting to possess it, or shouldering each other away from the trough When human beings carry this philosophy too far beyond the accepted standards, as did Jesse James and John Dillinger, we call them "public enemies" But this same philosophy of taking what we want from others, by violence and trickery, or by legalized strategy and force, has run all through human history.

But, in recent times, modern science has developed to give mankind, for the first time in the history of the human race, a way of securing a more abundant life which does not simply consist in taking away from some one else Science really creates wealth and opportunity where they did not exist before Whereas the old order was based on competition, the new order of science makes possible, for the first time, a cooperative creative effort in which every one is the gainer and no one the loser

For this reason, *I believe that the advent of modern science is the most important social event in all history* It marks the point at which men have come to understand themselves and the world they live in well enough to begin systematically to control the hidden forces of nature to their advantage Already science has done wonders to raise the standard of living and of knowledge, but these hidden forces are so great that we are assuredly only at the beginning of things possible

Some significant facts regarding the effect of the machine on the wages and employment of the worker are these Counting 1840 as about the year in which power machinery came to be important in the United States, we find a steady increase since that date in the ratio of average wages to average prices of commodities, so that it is now about seven times what it was in 1840 In other words, the average wage earner in America can to day buy seven times as much with his wages as he could in 1840; or more than twice as much as he could in 1910. Also despite increasing population and increasing use of labor-saving machinery, the percentage of our population gainfully employed increased 25 per cent between 1870 and 1930.

More material progress has been made during the past one hundred and fifty years under the American system of business enterprise than during all the preceding centuries in world history This record of achievement is a challenge to those who would radically change that system . Under this system, the United States, with a population of less than 7 per cent. of the world's total, controls about 40 per cent of the wealth of the world One hundred years ago the average person had about 52 wants, of which 16 were regarded as necessities To-day the wants number 484 on the average, of which 94 are looked upon as necessities.[3]

These facts, with their primary cause, are basic in enabling us to forecast the possibilities of improvement in the century that is ahead They make it well-nigh certain that we shall increase in economic well-being in the future just as we have in the past in just the proportion in which we continue to apply science and engineering to our industries and thus produce more and more in goods and services per man hour, thus freeing more and more men, more and more time, and more and more brains for education, for research, for art and for all the other service industries There is a saturation point for automobiles and radios, but there is no such thing as saturation in education or the service industries generally

Civilization consists in the multiplication and refinement of human wants It is a simple historical fact that these wants have actually developed with great rapidity wherever and whenever labor-saving machines have been rapidly introduced In 1900 60 per cent of our population was on, or supported immediately by, the farm, in 1930 not over

[2] "The Social Implications of Scientific Discovery." Published by the American Philosophical Society, Philadelphia, March 15, 1938

[3] This last paragraph of the quotation from Compton he in turn takes from a pamphlet distributed by the First National Bank of Boston.

44 per cent.[4] Without serious unemployment in that period the millions of displaced farmers found their way into garages, service stations, newly created secretarial jobs, news reporting, a newly created telephone service, advertising, insurance, gardening, domestic service and a thousand other service industries, and no serious or prolonged unemployment occurred until the enterprisers who normally create the new jobs began to be suppressed, legislated against and scared by unwise financial and political policies The faster science and engineering are applied to industry the faster we ought to progress There is literally no other way of comparable effectiveness to raise the standard of living, and the chief element in its effectiveness is in getting more power into the hands of the laborer so that he can produce more for himself, for in the last analysis the laborer taken as a whole gets under almost any modern social system practically all that he produces According to the United States Department of Commerce, in 1936 labor received directly 66 5 per cent of the national income Indirectly it received nearly all the rest of it, since the idle rich represent an insignificant fraction of the population and they pass on practically all that they receive to workers of some kind

My forecast of the future, then, must depend on what the future's sources of power are to be and on the cost of that power That is why I began with a consideration of the possibility of getting more work out of a pound of coal At present the main sources of power are coal and oil, with water playing a minor role and being in general more expensive. This situation will continue for a thousand years, for though the oil will perhaps be gone in fifty years, the coal will last for at least another millennium. The big steam plant is now nearly or quite as efficient as the best Diesel motor, but for small power purposes, motor vehicles and the like, the internal combustion engine is and will continue to be indispensable However, we already know how to make liquid fuel from coal, so that when the oil is gone we shall still be able to get liquid fuel for our internal combustion engines There are, I think, no other possible sources of power of comparable cheapness When the oil and the coal are gone we shall get our power either directly from the sun through solar motors, or wind mills or tidal machines, or else indirectly through growing and burning plants, but it will then cost us more than it does now So far as tapping the energy "locked up in the atoms" is concerned we can count that out We can of course do it now in principle through radioactivity, but I see no possibility fifty years from now of ever supplying the world's power needs, or even a minute portion of them, from any such source.

For the foregoing reasons, then, fifty years from now the world will look to us, from the point of view of power, not so very different from what it looks now Air travel will of course have increased, but the great bulk of the freight will go as now by surface vehicles or by steamships propelled in the essential particulars much as they are to-day The art of communications, too, is already a pretty well perfected art, and though it may be considerably cheaper than now, more messages being simultaneously carried over a given cable, so far as the techniques used are concerned I do not expect any very radical or startling change

Among the natural sciences biology has the opportunity to do the big new things so far as their immediate effect on human living is concerned, and I have no doubt that in the field of public health the control of disease, the cessation

[4] These figures are taken from the U S Census, which classifies as belonging to the "rural population" all persons living in the country or in cities, towns and villages of less than 2,500 inhabitants.

of the continuous reproduction of the unfit, etc., big advances will be made, but here I am not a competent witness, and I find on the whole those who are the most competent and informed the most conservative.

The most burning and most uncertain situation about the future has to do with social and political matters, and it should be remembered that all the foregoing forecast was based on the assumption that our present civilization would not be destroyed by man's present or prospective international wickedness, stupidity and folly. I know of no direct way in which science can prevent that, for I see no prospect of our ever being able to turn some new type of ray upon a dictator filled with the lust of power and conquest and thus transform him into a humanitarian. Indirectly, however, the sciences of explosives and poison gases, of aerodynamics, of communications with its corollary, the rapid spread of *knowledge* among the people, are doing the work. It was the fear of the bombing of London and Paris that prevented the beginning of another world war last September. The peoples of all countries, including the dictatorships, are coming more and more to the realization that such another war can bring only death and destruction to everybody—the end of civilization, not the world domination which the demagogic leader promises. It is the rapid spread of knowledge by the effective methods that modern science has developed that gives good ground for hope that a world war will not come. The science of geology has shown that something like three fourths of the coal and the metals, the ultimate sources of power, are in the democratic countries. This fact together with the knowledge that these countries can be and have already been roused to arm to defend themselves is the great influence that makes for continued peace in the world to-day and that gives promise that a permanent method of assuring peace may ultimately be worked out. But these countries must have the intelligence, the long-range selfishness to see the hopelessness, the folly at a time like this of a policy of division and isolation. They must obviously, it seems to me, *join their powers* in time to show the international bandits the hopelessness of their threatened spring at the throat of the world. If they, including ourselves, will do this, then I think there will be no war, and then I stand by my prognosis of a golden age ahead through the further growth of science and its application to the well-being of mankind.

SEA FLOORS OF GLACIER NATIONAL PARK[1]

By Dr. CARROLL LANE FENTON
WASHINGTON, D C

NEAR the northwestern corner of Montana lie what Meriwether Lewis called the "shining mountains" Peaks of buff, red and green rise in two ranges, blue lakes extend from the plains into valleys walled by many-hued rocks Yellow flowers grow at the edges of snowdrifts, while in high, snow-swept basins the ice of sixty glaciers gleams They, and much greater ice streams of the past, give their name to Glacier National Park

The region has contrasts as well as color Meadows surround vast rock-heaps, canyons alternate with cliffs In the valleys are tall Douglas firs and cedars, while passes support stunted pines and willows whose catkins stand barely two inches above the ground Along the eastern border of the Park, mountains rise abruptly from plains, and old rocks stand on top of young ones Those old rocks form every high ridge and peak—yet their beds contain beaches and sea bottoms, and show how storms swept muddy shallows, 650,000,000 years ago

A topsy-turvy, paradoxical jumble? It seems so to many a tourist who tries to grasp it as he travels by bus or heavy-footed cayuse It is less confusing to those who walk, for they have time to look, to think and to piece misplaced sections together In the end, hikers have a story which "makes sense," even though it does mingle upheavals with such every-day affairs as wind and sandstorms blown from dry hills

This story begins in the late Proterozoic Era, some 650,000,000 years ago North America existed in these days, of course, but it was not like the continent across which we travel to-day It probably was bigger and warmer It also supported at least two seas One of these spread northward across Arizona, at least as far as Wyoming The other advanced from the Arctic Ocean In time, it probably joined waters with the sea whose shoals and muds now lie far down in the Grand Canyon

Rocks of the "shining mountains" were formed in the sea that came from the Arctic Ocean That sea was long, narrow and shallow, the part of it which we know best was never very far from land Rivers flowed from that land, bringing loads of sand and silt, as well as dissolved minerals such as dolomite and lime For millions of years these sediments gathered, while the sea bottom intermittently sank At last it held a varied series of rocks whose full thickness is 60,000 feet

At this point there is a gap in the story, a gap which must be filled in from rock-records in other parts of Montana They show that the Proterozoic Era ended with uplift which built mountains The mountains then were worn away, the country began to sink, and new seas advanced from the Arctic Though they never were very deep at one time, their basins sank repeatedly, and so allowed vast amounts of sand, silt and mud to settle in the basins Where they can be found, these deposits tell events of the Paleozoic Era, which lasted 350,000,000 years

This brings us to the Era of Reptiles, and back to the region of Glacier National Park Sinking again gave way to uplift, and rocks that had lain beneath the sea were pushed upward into swampy land

[1] A detailed statement of evidence on which conclusions in this article are based has been published in the *Bulletin of the Geological Society of America*, 48 1873–1970, 1937

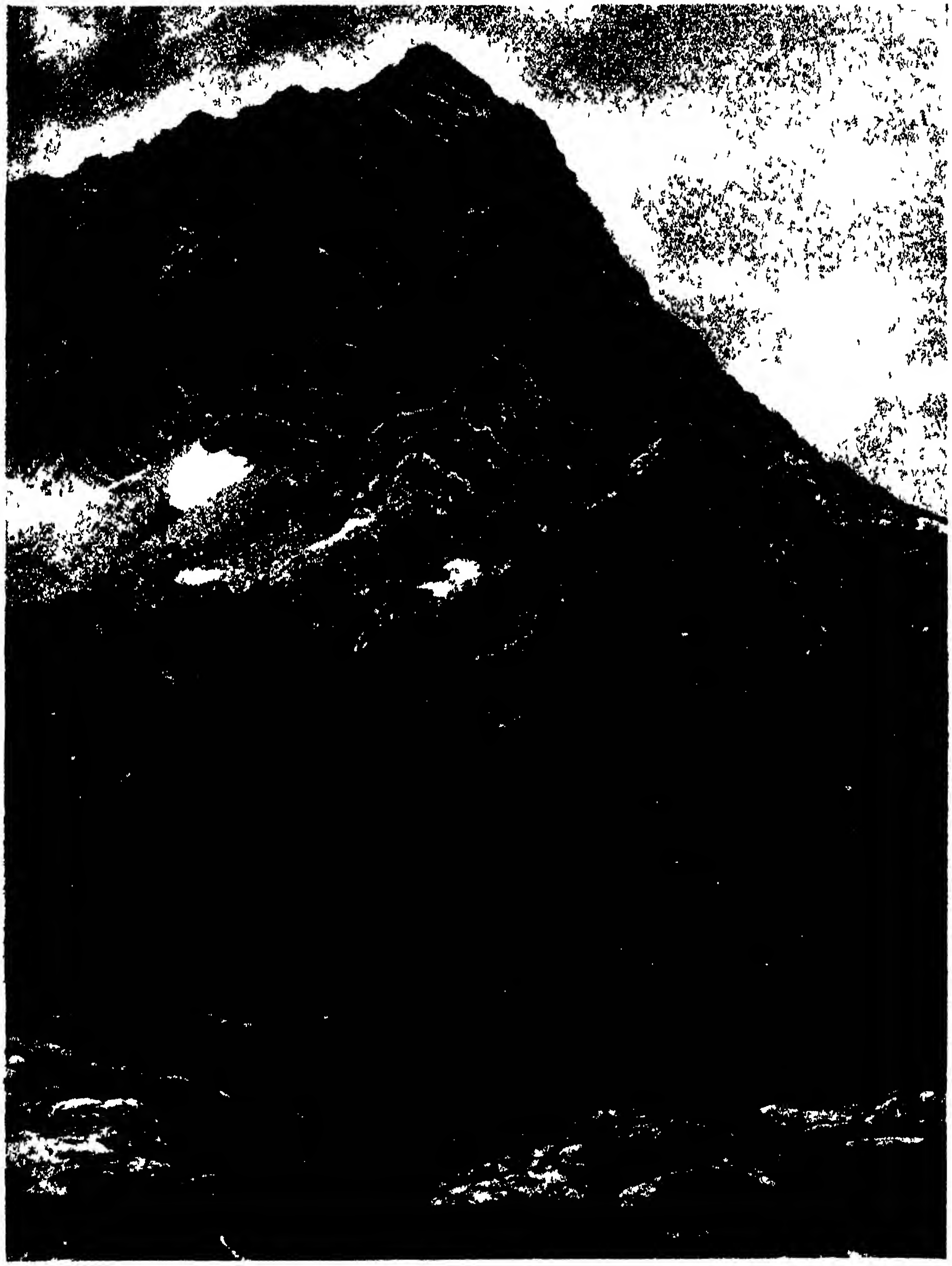


Photo by Hileman

BEDS OF RED AND WHITE STONE

WHICH SETTLED IN A SHALLOW SEA MORE THAN 600,000,000 YEARS AGO THEY WERE BENT, BROKEN AND PUSHED ACROSS ONE ANOTHER WHEN UPLIFT MADE THE MOUNTAINS OF GLACIER NATIONAL PARK.


(C) *Photo by Hileman*

HARDENED, RAISED SEA BOTTOMS

FORM SCENERY IN THE "SHINING MOUNTAINS" HERE, GRINNELL GLACIER IS DIGGING THE MARINE ROCKS AWAY ALONG THE CONTINENTAL DIVIDE

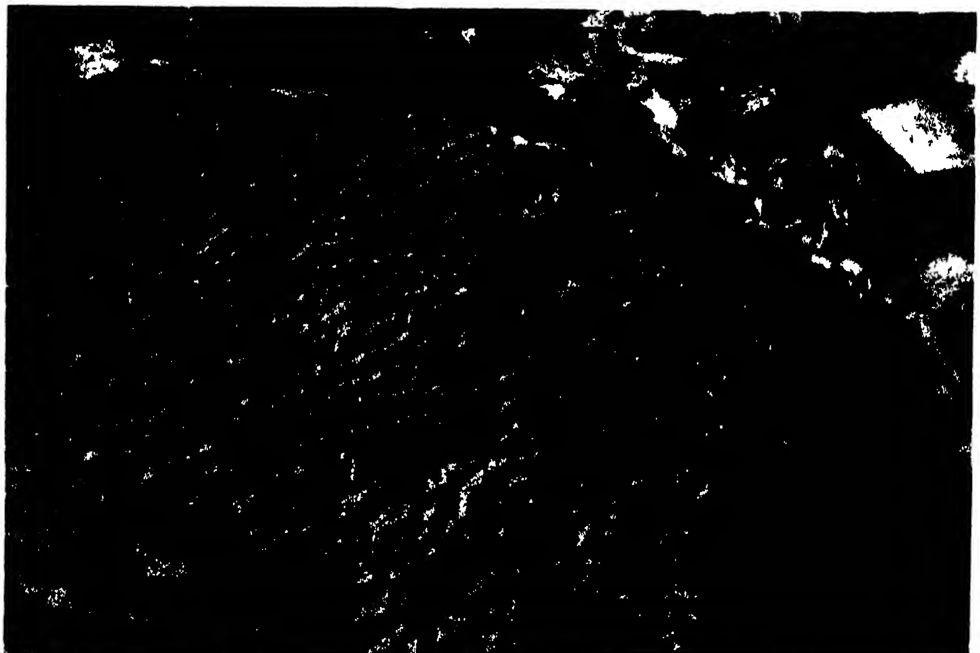
In those swamps appeared dinosaurs with short forelegs and ducklike beaks, as well as others whose bodies were sheathed in armor They wandered through glades which to-day are bare plains of the Blackfeet Reservation Then they fled before a Cretaceous, or Chalk Age, sea whose muds now lie beneath the mountains as well as in ridges near them

Soon—geologically soon—that sea itself began to retreat A tremendous force, pushed from the westward, squeezed and bent the rocks that had settled in the basin through two long eras Before this force, the strata heaved upward in folds, pushed still farther, they crumpled and broke, moving upward and eastward more than thirty miles When the earthquakes of uplift ceased, mountains of Proterozoic rock stood upon beds of Cretaceous age stretching eastward to form the plains Between them lay the Lewis Fault the break along which the mountains moved, representing a gap in time of two geologic eras and about 600,000,000 years

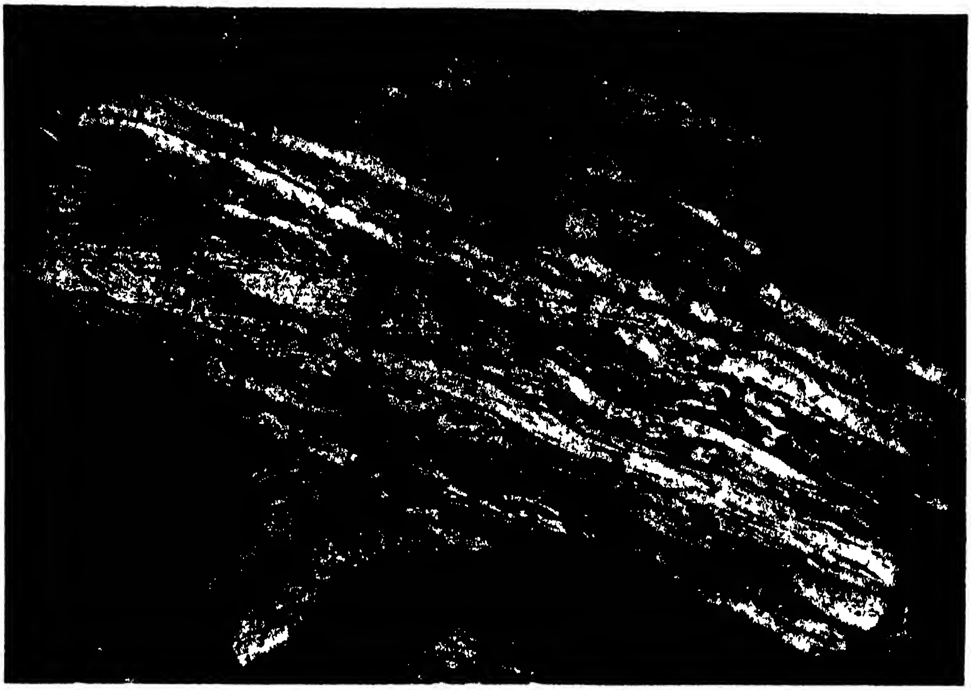
Though crumpled and shattered near the line of uplift, the mountain-forming rocks suffered slight change Appearing much as when they were formed, they link the past with modern scenes of valley, peak and glacier, recording conditions with range from shifting winds to advances of sea, they reveal ancient environments in often surprising detail Since fossils occur in many beds, their structures (coupled with sediments) show how very ancient life met environmental demands.

The scenic importance of rocks first impresses the visitor He sees mountains whose colors are more varied than those of the Grand Canyon—each color the product of special events in which land, streams and sea combined He finds that low limestones make waterfalls, while

RIPPLE MARKS
MADE BY CURRENTS WHICH SWEPT ACROSS A SHALLOW BAY WHEN WESTERN MONTANA WAS A SEA. SUCH MARKS ARE STEEPER ON ONE SIDE THAN ON THE OTHER



RECORDS OF SHIFTING WINDS
THESE WAVE MADE RIPPLES ARE EQUALLY STEEP ON BOTH SIDES. WHEN THE WIND CHANGED, WAVES BUILT NEW RIPPLES ACROSS OLD ONES



CROSS BEDDED QUARTZITE

THIS SANDY STONE CONTAINS PEBBLES WASHED INTO SHOALS BY STORMS

high ones form steep cliffs Red argillites produce pinnacles and ridges, greenish ones underlie gentle slopes or appear in low, rounded peaks Thus varied Proterozoic muds have controlled mountain sculpture by frost and streams, as well as the work of glaciers that spread during the last Ice Age

Those who seek ancient environments are concerned with smaller features than these Formations furnish a general scheme, but the countless strata and layers of which they are built hold those detailed records of change which tell how deep the ancient sea was and how salty They trace its shiftings, its currents and its waves Some even tell how fast sediment settled on its bottom

Let us start with the rate of sedimentation Some beds of rock are thick and are made of coarse pebbles and sand, they show rapid accumulation near the mouths of heavily laden streams Other beds are fine mudstones or lime in layers almost paper-thin Some strata of green argillite (a shale-like stone) show 56 distinct layers to the inch If each layer is a summer's or a winter's mud, that inch took 28 years to form

But is each layer a season's deposit? That question is answered by finely banded marble which lies below the argillite Bands in this marble are dark and light, the dark ones being made by carbon which came from simple water plants Such plants grow abundantly in summer, when light is strong, they grow slowly or not at all in the winter, when sunlight is scanty The evidence becomes specially convincing when we trace carbon-rich layers of stone directly into colonies of fossil plants, and find that these layers not only are dark, but are much thicker than layers which have very little carbon

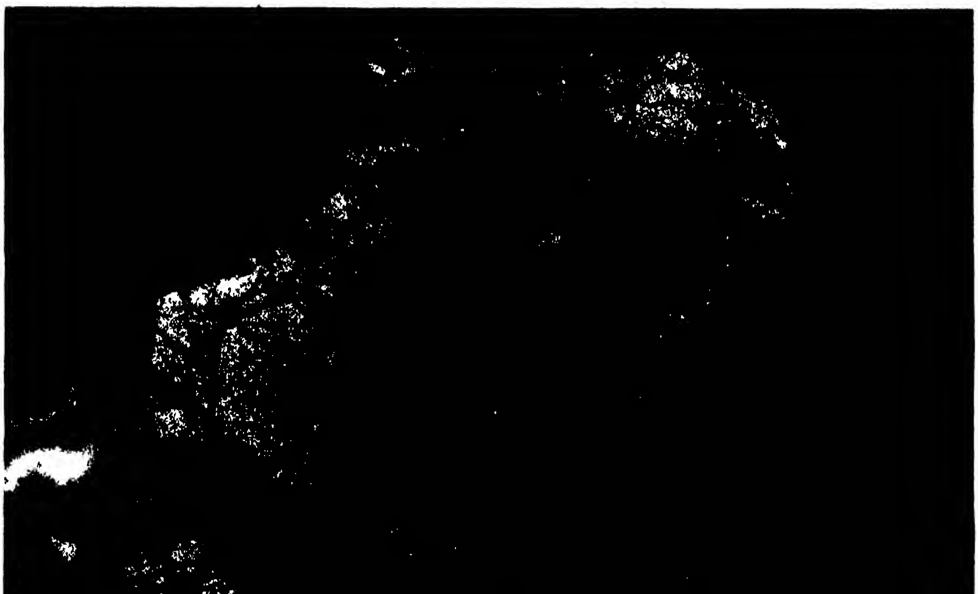
With a little practise, this method can be extended to beds in which carbon is scarce It also can be used to interpret layers so thin that their rate of accumula-

tion was almost unbelievably slow In one series of mudstones which appear high in the mountains, many layers accumulated at a rate of 60 to 75 years per inch, while some show the almost unbelievably slow rate of 340 years for a single inch of stone

These beds mean quiet as well as shallow water—yet such conditions were not the rule Beds of limestone, shale and sand unite in bearing ripple marks that were made when breezes swept the shoals in which they were deposited When the wind changed it built new marks cutting those already formed, sandy beds near Swiftcurrent Pass abound in cross ripples so perfectly shaped that their crests enclose almost exact squares Breezes were uncertain indeed on that special Proterozoic bay

Currents also swept near shore, building ripple marks with one side steep, not symmetrical like those of waves They often are found with criss-crossed layers of alternating mudstone and sand Such cross-bedding is one mark of shoals across which conflicting currents swept, breaking the sediments beneath and dropping the fragments at varied angles It often appears in river channel deposits and dunes, but no clear trace of either has been found within Glacier National Park

But what are these dark red lumps scattered among beds of white sand? They seem to have rolled, snowball style, over a surface of sticky mud Storms set them on this path to growth, reaching shallows, they stranded in sand when the waves or currents became too weak to carry them farther The balls settled among a mixture of sand, pebbles and chips of partly-hardened mud which were torn from the sea bottom while the mud balls were rolling about

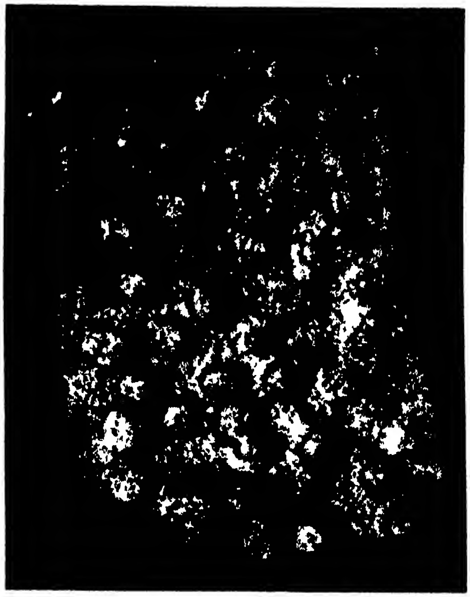


MUD BRECCIA

THE LARGE PEBBLES ARE MUD WHICH STORMS TORE FROM THE SEA BOTTOM AND MIXED WITH COARSE SAND FROM THE LAND.

Those storms did not advance into shoals from the open sea. Instead, they apparently began on land at the end of each dry, or summer, season. Break of the drought was heralded by gales which carried sand and pebbles seaward from the semi-desert hills. Then cloudbursts revived dry streams, turning them into floods that carried vast quantities of sediment to the wide-spread shallows near shore. There they took up layers that had partly hardened, rolled sticky mud into balls, mixed fragments of all sorts together, and then allowed them to settle in strata whose technical name is *mud* or *edgewise breccias*.

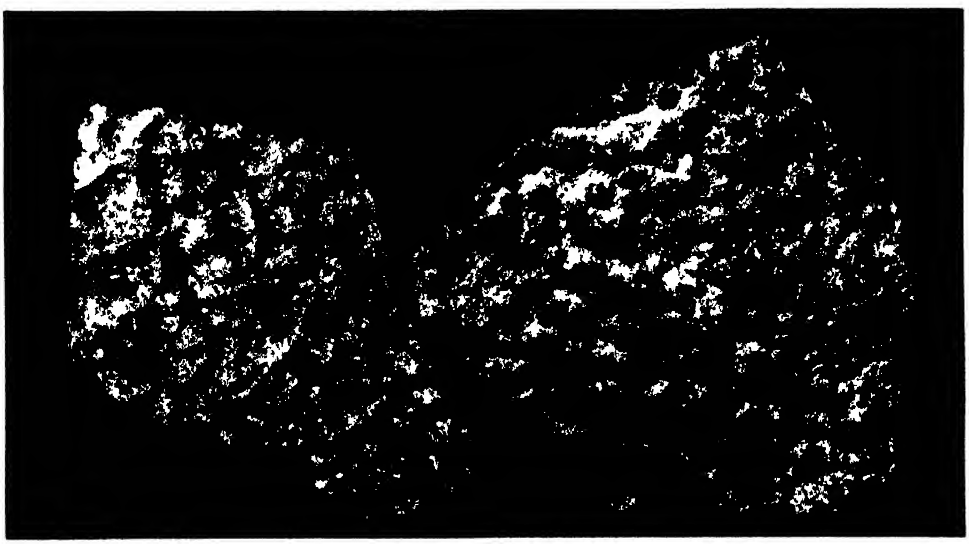
These breccias mean that water was shallow, much shallower than that of most lakes. Over thousands of square miles and through millions of years, the Proterozoic sea bottom lay so near the surface that each dry season laid it bare. Then sand flats or mud flats steamed in the sun, to be pelted and pitted by rains that fell before they had time to harden. Hail dug even sharper pits, whose oblique angles trace directions of wind through which the hail-stones fell. Often a single sandy ledge records storms of both land and sea in its cross-beds, mud balls, pebbles and rain or hail pits.



RAIN PRINTS

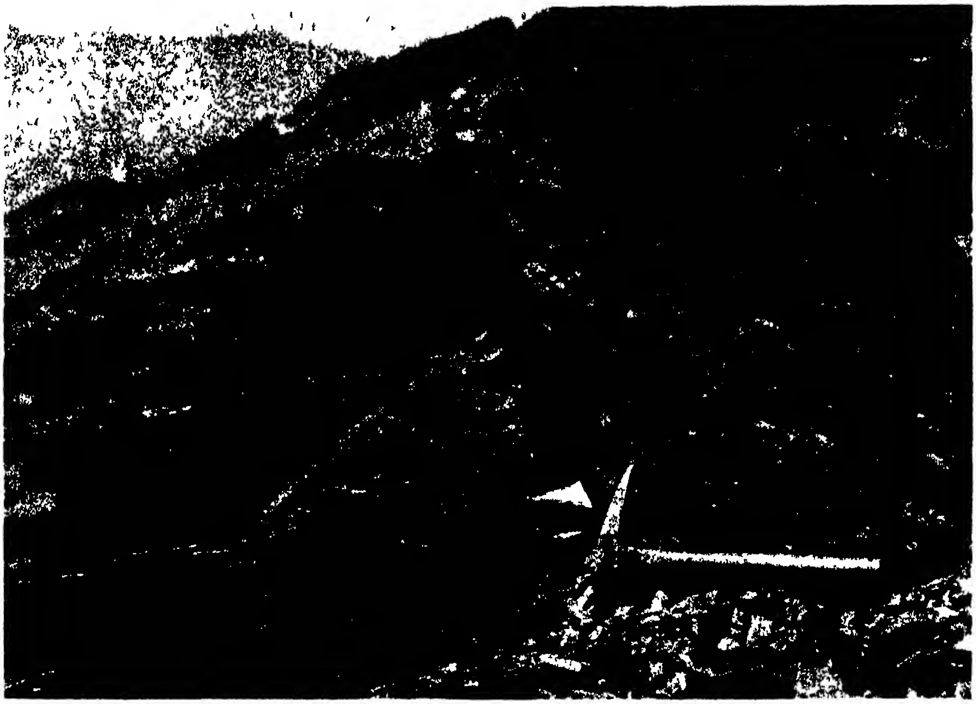
ALMOST 650,000,000 YEARS OLD. THEY WERE MADE IN PLASTIC, BLUE-GREEN MUD

It also may show that the muds dried and cracked, as pond muds do to-day. Unlike pond muds, the edges of cracked



SLEET PRINTS AND FILLINGS

ON THE LEFT ARE PRINTS MADE BY SLEET, DRIVEN BY A SOUTHWEST WIND. ON THE RIGHT IS A PIECE OF HARDENED MUD WHICH COVERED AND FILLED THE SLEET PRINTS



CRACKED MUDS
OF A SEA SO SHALLOW THAT THOUSANDS OF SQUARE MILES LAY BARE, DURING EACH DRY SEASON THE LARGE SLAB SHOWS THE UPPER SIDE OF A BED, THE SMALL ONE, THE UNDER SIDE NOTE HOW THE CRACKED EDGES TURN DOWNWARD

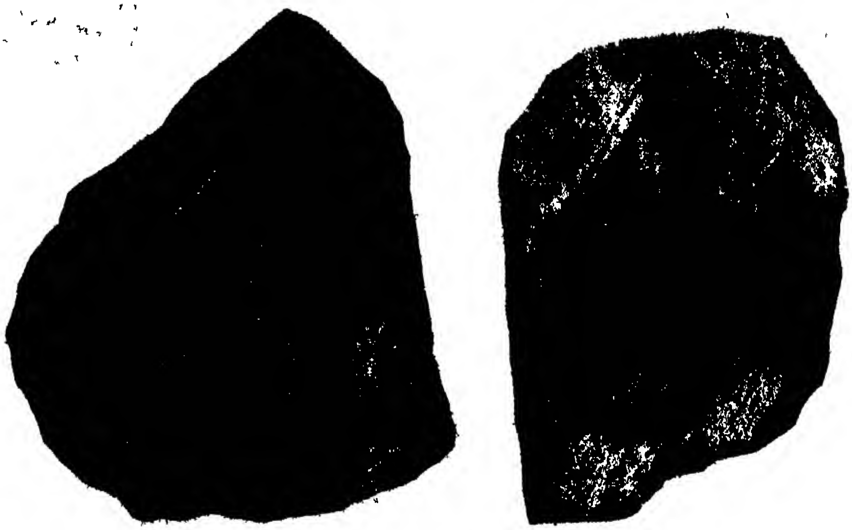
Proterozoic muds turned down or refused to curl—a situation reproduced to-day if we dissolve salt in fresh water silts The more salt we add, the more the edges curl downward as water in our test pan evaporates a clue to shifting salinity in seas whose sediments are variably cracked

But must the rocks of Glacier Park be marine? There are two theories which hold they are not One of these theories pictures these strata as deposits in a chain of inland lakes, thus accounting for their seeming lack of fossil marine animals The other theory compares the rippled, mud-cracked beds to those left when streams overflow and cover adjoining plains with silt It would make at least three fourths of these rocks the products of such seasonal floods

The latter explanation is hard to believe Though streams contain very little salt, saline mudcracks are the rule in strata of Glacier Park Many strata also contain sandy cubes which are casts of salt crystals formed when shallow waters evaporated Yet these very beds are supposed to be silts left by overflowing streams!

But why not a great salt lake? It would have to be very great indeed, for the basin filled by these sediments would have held twenty lakes the size of Superior Though shifting, it sank through millions of years while 60,000 feet of rock were carried down from its shores Only seas are known to last so long, and as seas we may regard the waters that swept Montana in Proterozoic times

With this the story of fossils agrees For animals it is incomplete. two slabs bearing burrows of worms that bored in a beach of fine, brown sand, and two marks that seem to be clam trails Supposed crustaceans prove to be broken



MARINE LAMP SHELLS

OR BRACHIOPODS FOUND NEAR THE BIG BELT MOUNTAINS OF MONTANA, IN ROCKS EQUIVALENT TO THOSE IN THE WALL OF ICEBERG LAKE CIRQUE

Photo by Hileman

CIRQUE WALL OF ICEBERG LAKE

CUT BY AN ALMOST VANISHED GLACIER THE LIGHT GRAY BAND IS A BANK OF FOSSIL ALGAE, ABOUT 100 FEET THICK

CONE SHAPED ALGAE
OF THE SORT THAT BUILT THE BANK ABOVE ICEBERG LAKE AND THE REEF SHOWN IN THE FOLLOWING PICTURE

fronds of brown seaweeds, eleven shells from the Big Belt Mountains undoubtedly are marine Although these shells were found 150 miles from Glacier Park, they lay in rocks whose age was identical with the "limestones" (really dolomites) which form much of the Continental Divide in the Park and northward into Alberta These are the rocks whose supposed lack of sea animals was turned into evidence that the "limestones" settled in freshwater lakes

Though animal remains are few, fossil plants of the group called algae are common At the very foot of the mountains they appear in gray marbles that weather to brilliant buff When broken, some strata show irregular films of black—the supposed crustacean shells Those films actually are remains of seaweeds which looked somewhat like the modern rockweed, but grew on muddy banks If abundance as fossils means abundance in life, those seaweeds were common and wide-spread

A few feet higher lie massive beds of closely packed, oblique columns Each column is oval in section, consisting of hundreds of convex layers resembling saucers piled bottom-side-up Though opinion is not unanimous, it seems certain that these columns were built by colonies of filamentous algae, each of which deposited layers of lime in the jellylike mass surrounding its fibers Thus, even while alive, these plants built rocks which were firmer than the muds that settled in less populous bays

The thick green and red formations have not afforded one fossil plant But scarcely did lime bottoms return when a new sort of alga appeared, spreading out in biscuits or domes, or crowding into compact beds which are as black as coal Though now largely dolomite, the algal filaments provided carbon enough to stain

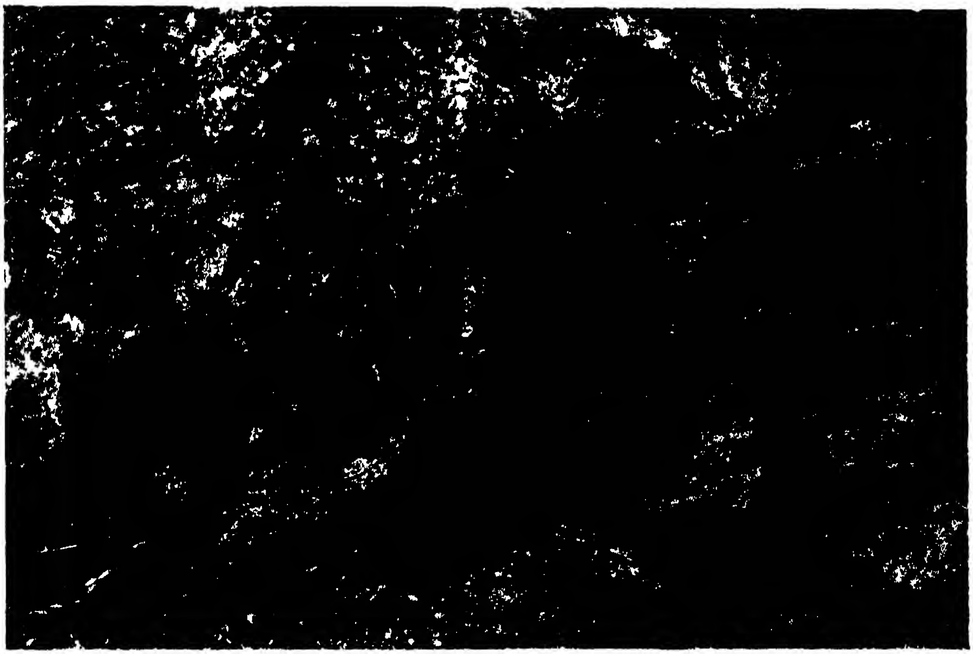
that rock black and to color the adjoining beds

Scattered widely through Glacier Park and in southern Alberta as well, these fossils are most abundant on two of the southern passes There they lie among dwarf willows and snow, above slopes where strange alpine plants sink roots two feet into the soil as anchors for three-inch crowns of leaves Again one contrasts the alpine present with a past of seas and primitive plants whose life processes built layers of stone

Still higher are ledges about a hundred feet thick, formed by conical colonies On exposed spots they expand into sheets —apparent proof that two "species" are one and that early algae varied in form according to varied conditions of life As a matter of fact, several true species of algae probably combined in each of these ancient colonies, just as they do in modern growths One group of species made the columnar fossils, another produced the black masses, and still a third made the cone-shaped colonies which form the massive gray ledges that show plainly in the buff cliffs of almost every high mountain in the Park

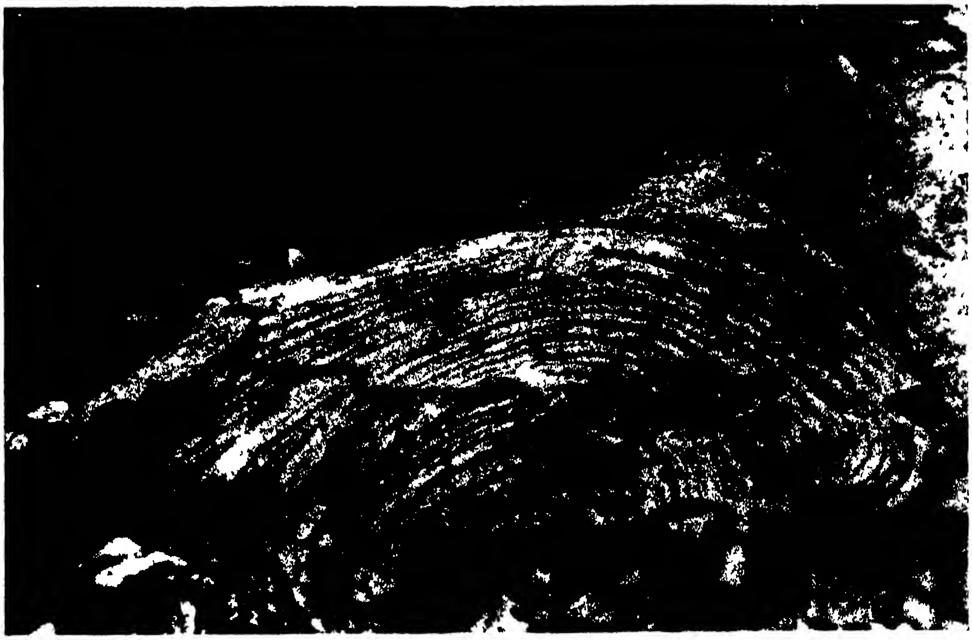
Some geologists call such massive beds reefs, though a reef should be a dome or ridge For decades no true reefs were known from Proterozoic rocks in the northern Rockies Now, trails pass several small ones, while a trans-mountain highway has cut two whose perfection fits them for text-books They show the low central core, or ridge, composed of conical colonies whose weight squeezed and compressed the soft muds on which they grew These squeezed, depressed layers prove that reefs can develop on soft bottoms as well as the hard platforms which are furnished by stony banks or submerged volcanoes

These reefs also show how greatly the plant colonies indulged in ecologic variation Where crowded, they formed compact cones, at the reef edge, where currents swept, they spread out in wrinkled



A REEF OF LIMY ALGAE

WHICH GREW ON MUD SO SOFT THAT THE WEIGHT OF THE REEF BENT IT DOWNWARD GOING-TO-THE SUN HIGHWAY, 6 4 MILES NORTHWESTWARD FROM LOGAN PASS



SUBMARINE LAVA
PART OF A FLOW WHICH COVERED LIVING ALGAE AND BAKED THEM INTO REDDISH BROWN LUMPS

sheets. Where crowding was not intense, they assumed spongelike forms, while out on the open, uncrowded mud they grew in irregular, flattish masses. An associated "species" grew in closely packed columns, while another (which grew away from the reefs) formed flattened biscuits of stone whose widths reached 5 feet. Where water was very shallow and waves secured a great deal of air, these biscuits fused into compound colonies 8.5 feet in diameter and 3 to 4.5 feet thick.

Though these colonies varied according to different surroundings, they met no such problems as those that faced plants which are found in greenish shales near the crest of the Continental Divide. These algae lived on shallow, wave-swept shoals on layers of hardened, deeply cracked mud that a few months before had been land. Currents and storms swept these shoals, overturning small colonies and piling layers of mud upon others that were too massive to be disturbed. At times the sea water disappeared, allowing both plants and mud to dry out, at others, submarine lavas poured forth, baking the algal colonies to brittle balls that now are covered by lumps and ropy twists of lava. Between eruptions the plants returned, only to meet a similar fate when new cracks opened and more lava emerged. They could find no peace in a steaming sea which dried or was flooded between eruptions. Even when lava no longer poured out, these algae failed to regain foothold in the bays. Though they may not at once have become extinct, they vanished from the records of Glacier Park.

The import of those records is clear. They link the present with the past—not merely in scenery, but in waves, winds, rivers, sea floors and even submarine eruptions. They present early environments with detail not achieved for many later seas, whose deposits are much more familiar. Finally, they show simple organisms living as simple things live today, meeting failure or success as conditions and their own abilities decide.

SPANISH METHODS OF CONQUEST AND COLONIZATION IN YUCATAN, 1527–1550

I. ROYAL POLICY

By Dr. ROBERT S CHAMBERLAIN
THE CARNEGIE INSTITUTION OF WASHINGTON

PORTUGAL and Spain were the leaders in the great movement which has been termed the Expansion of Europe They were the first of the states to create colonial empires in the modern sense, the former laying the foundations for overseas expansion in the mid-fifteenth century as a result of the activities of Prince Henry the Navigator, and the latter through the discovery of the New World by Columbus at the close of the century The empire of Portugal was, with the exception of Brazil, wholly maritime and commercial, consisting of islands and trading stations along the sea lanes around Africa to India, the Spice Islands and China, that of Spain was continental With her slender resources, Portugal held her possessions but thinly and soon lost her importance, Spain, with her greater population and wealth, from the first directed her efforts toward true colonization and, in an almost incredible display of spiritual and material force, created one of the greatest overseas empires which history has witnessed while simultaneously engaged in establishing her hegemony in Europe

Being first in the field, in establishing their overseas empires and therein creating something which had hitherto not existed, Portugal and Spain were forced to rely entirely on their own native talents They could look to no other peoples for guidance, and they could not rest their policies on the experience of any others

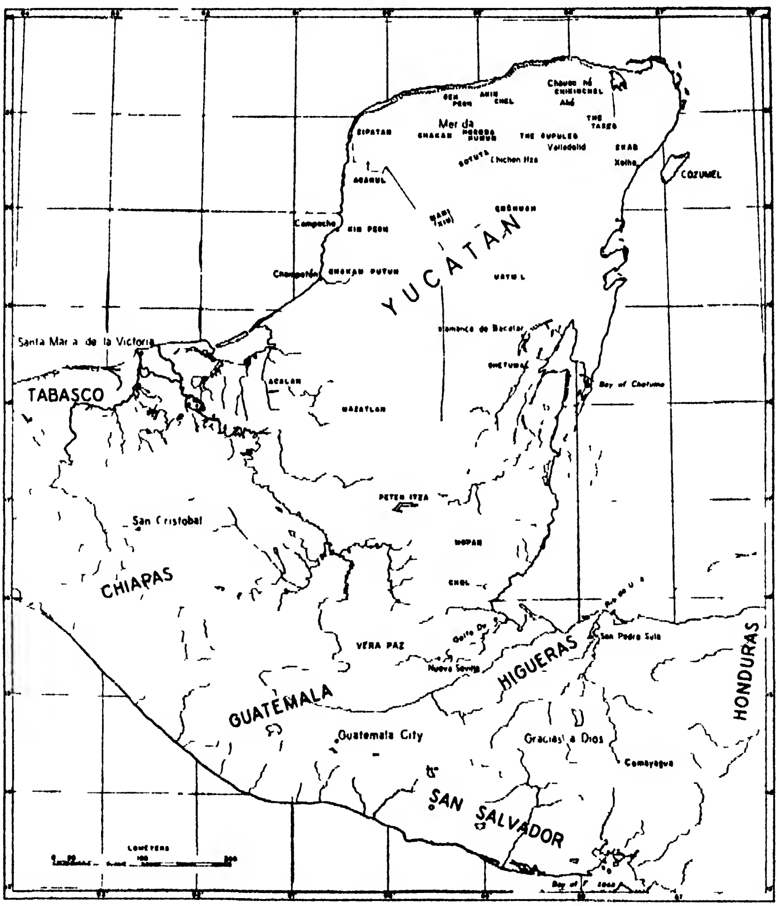
The Spanish lands of the New World pertained directly to the Crown of Castile, and it was consequently the sovereigns of Castile who were required to meet the extremely complex problems arising from the creation of a vast colonial empire in lands heavily populated by unknown peoples, certain of whom possessed ancient and relatively high cultures All activity toward colonization derived from the Crown as the sole source of authority and the proprietor of the lands concerned In this connection it is to be noted that among the Spanish kingdoms it was Aragon, through her Mediterranean holdings, and not Castile, which had gained experience in the administration of overseas possessions The sovereigns of Castile to the very year of the discovery of the New World had been engaged in the *Reconquista*, consummated by the conquest of Granada, and had been concerned with the consolidation of their realms and the establishment of their supreme authority Castile heretofore had not turned her attention outward, and in solving the problems of overseas colonization she was forced to build from the ground up

The efforts of the Spaniards in the field of colonization have all too frequently been lightly dismissed, especially by Anglo-Saxons, as those of a people who possessed no aptitude for such endeavor and who had no objectives other than to wring from the natives, the mines and the soil the last ounce of personal profit The early colonists have been represented as little more than bands of utterly cruel and rapacious, if indeed amazingly daring and courageous, conquerors, who killed, robbed and oppressed for no other purpose than to achieve sudden wealth in its most tangible form, that of gold The

policies of the Crown have been regarded as those of thoroughly unenlightened, intolerant, oppressive, despotic and heavy-handed absolute monarchs who, disregarding completely the welfare of colonists and Indians alike, sought nothing more than the full exploitation of the overseas possessions in their own benefit and in that of the metropolis

On the opposite extreme are those of a so-called revisionist school, who in comparatively recent years have presented a wholly favorable picture of a beneficent government which brought to the Indians the blessings of a higher civilization and a true religion Unfavorable aspects of government, conquest, colonization and the Church have been glossed over, rationalized or explained away, and the frequent wide divergence between the theories, policies and intent of the Crown on the one hand and the actual practices and conditions on the other has been ignored, as has the Spanish tendency toward legalism and formalism, which at times engenders strict observance of the letter and form, but violation of the spirit and intent

Both contentions have bases in actuality, and, as is almost invariably the case, the truth lies at some undetermined point between the two extremes It is my purpose briefly to analyze, compare and contrast various aspects of the policies of the Crown on the one hand and on the other the actual practices as exemplified in



Drawn by Edwin M Shook

A MAP OF THE MAYA AREA, 1527–1550

CHICHEN ITZA AND SURROUNDING COUNTRY, LOOKING EAST

The principal structures in the background are, from left to right, the Ball Court, the *Castillo* and the Temple of the Warriors. The group in the foreground to the left consists of the *Casa del Venado*, the *Casa Colorado*, the *Casa de Monjas*, the *Caracol* and the *Akab 'Dzib*. Between the lines of the former and latter groups of structures is the *Osario*. To the right in the foreground is the *hacienda*, now headquarters of the Carnegie Institution of Washington, and the chapel. It was among, or close to, these buildings, already abandoned by the Maya, that the Castilians, late in 1532 or early in 1533, established the short lived city of Ciudad Real. According to the most recent reconstruction, the history of Chichen Itzá is briefly as follows. Founded at an uncertain date, Chichen Itza was occupied by Yucatecan Maya until A.D. 889. This is the period of pre Mexican architecture. There followed, from 889 to 987, an era of inactivity. From 987 to 1185 the Itzás, a Mexican people under the semi legendary Quetzalcoatl, or Kukulcan, as he was known to the Maya, occupied the city. A period of great architectural activity ensued, in which new forms, based on the worship of Quetzalcoatl, the Feathered Serpent, were introduced. Kukulcan founded Mayapan as a political capital, and a league of the three foremost cities of Yucatan, Mayapan, Chichen Itzá and Uxmal, known as the League of Mayapan, was formed. Chichen Itzá remained an important religious center. The league, under the dominance of Mayapan, remained supreme in Yucatan until the mid fifteenth century, when internecine strife led to its break up, the destruction of Mayapan and the abandonment of Chichen Itzá. Yucatan thereupon fell apart into relatively small independent *cacicazgos* and a period of political decadence followed. There was, however, something of a revival of Maya influences in the crafts.

the conquest and initial colonization of Yucatan.

In approaching the subject of the methods of conquest and colonization two factors must be borne in mind, as has just been inferred: first, the policies and intent of the sovereigns of Castile, which are well set forth in the "Recopilación de Leyes . . . de las Indias," published in 1680, one of the greatest of colonial codes, and, second, the acts and purposes of those who carried Castilian dominion to the Americas. Conquest and colonization were given their character by the interworkings of these two factors, and the latter often negated the former, at least temporarily. The sovereigns through laws and ordinances established the norms within which, exercising considerable initiative with respect to methods and specific policies, the *conquistadores* reduced and settled the lands over which they were delegated authority. In this regard, it is to be pointed out that the full forms of absolute royal government were not established until after the great conquests had been achieved and initial colonization had been begun.

The Crown had as its objectives the expansion of its realms, the gaining of

THE *CASTILLO*, CHICHEN ITZA
This view shows the structure as it appeared during the visits made to Yucatan by the American diplomat and explorer, John L. Stephens, in 1839–1840 and 1841–1842. The drawing was made by Frederick Catherwood, an English artist and architect who accompanied Stephens. The *Castillo* was dedicated to the worship of Kukulcan, or Quetzalcoatl, the patron deity of Chichen Itzá.

further subjects, the increase of revenues and the Christianization of the Indians and the winning of them for the Roman Faith. The *conquistadores* and other early colonists were motivated by many and varied forces: desire for opportunity denied to them in Castile, the wish for personal wealth and position quickly and readily achieved, desire for glory and love of adventure, the desire to serve their sovereign and add to the luster of his throne, the crusading spirit and, to a certain degree, in instances, a sincere desire to aid in the winning of souls for the True Faith.

The principal problems before the Crown were the establishment of government, economic institutions, the Church and social forms, the latter of which, resting on religious bases, were centered in the relations between the natives and the Castilians and the legal status to be given to the Indians. The political and economic problems with which the sovereigns of Castile were confronted were in the broader sense common to all colonizing states, but the religious element assumed a vital importance with respect to Castilian colonization which it possessed nowhere else.

The sincere religious zeal of the Crown can scarcely be overemphasized, and it is to be remembered that the crusading spirit was strong in Spain after the centuries of the *Reconquista,* which, significantly, is also known as the Perpetual Crusade, and that upon the conquest of Granada this spirit was projected outward. Closely related to this religious zeal was the equally sincere desire of the Crown for the well-being of its Indian vassals. The Christianization

of the natives, their entrance into the fold of the Church and their welfare was invariably declared by the sovereigns to be "our principal desire and intent," and there is no reason to doubt this declaration as a sincere statement of purpose To gain an appreciation of the importance of the religious motive it is only necessary to recall the aims of Isabella, the policies of Charles V, who, with all his vast political responsibilities as Emperor and King of Castile and Aragon, never lost sight of his objectives of reforming the Church and of healing the breach between Catholics and Protestants and bringing the latter once more within the fold of Rome, and the purposes of Philip II, who, however intolerant, regarded himself as a chosen instrument of God to restore the unity of Christendom within the Church, extirpating what he believed to be the false doctrines which were rending the seamless robe of Christ

The conquest and colonization of the New World consequently has two aspects, the temporal and the spiritual The subjugation of the natives by force of arms or by peaceful means, the settlement of conquered lands and the establishment of governmental and economic forms on the one hand and the establishment of the Church and the effort to win the Indians to Christianity and the Church on the other, everywhere proceeded simultaneously

It should be emphasized, furthermore, that the Crown considered its claims to dominion over the New World to be juridically above question, as the lands and peoples of the Americas had been given into the power of the sovereigns of Castile by the Pope In accord with this theory it was not only the right of the Castilian monarchs to bring the New World under their control, but their obligation, and in so doing they regarded

THE RESTORED *CASTILLO*, CHICHEN ITZA, VIEWED FROM THE NORTH
The temple, eight meters in height, was built on the great pyramid, sixty meters square at the base and twenty four meters high Great structures of this kind erected by the Maya served as places of worship, as government buildings and as dwellings for the rulers, priests and nobles The restoration of the *Castillo* was carried out by the Mexican Government

NORTHWESTERN FAÇADE, TEMPLE OF THE WARRIORS, CHICHEN ITZA
Showing the intricate stone work and skilled carving of the Maya buildings. The stones, set into mortar and rubble, form a veneer. At the corners and on the walls are elaborate masks and shields, and in the doorway are serpent columns, symbolic of Kukulcan, the Feathered Serpent.

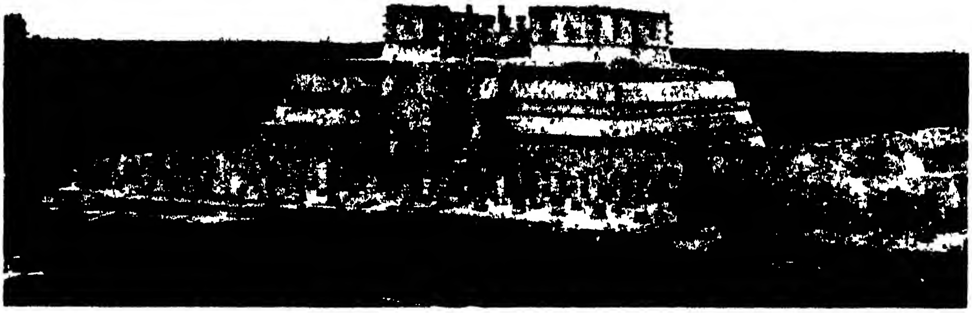
themselves as bound to conform with the principles of divine and natural law and justice, thus to maintain just title. The natives of the Indies were already their vassals, and were obligated to acknowledge their dominion, and in establishing effective control they were making actual a condition which already existed in theory. Natives who did not immediately accept their dominion were consequently "in rebellion" against their rightful lords.

The broader policies of the Crown with respect to the conquest and colonization of the Indies are indicated in the *capitulación*, or patent, by which Charles V, on December 8, 1526, assigned to Francisco de Montejo authority to reduce and settle the "Islands of Yucatan and Cozumel," with the titles and offices of *Adelantado*, Governor and Captain General, the first hereditary and the latter two for life. These offices conferred upon Montejo superior political, judicial and military authority within the lands concerned as a representative of the sovereign. Montejo was to conquer and colonize Yucatan at his own cost, and was to receive in hereditary grant four per cent of the revenues originating within the province from whatever source. An area ten leagues square within the province was assigned to the *Adelantado* to be held in perpetuity. At least two towns, each of a minimum of one hundred citizens, were to be founded, and two fortresses were to be constructed. To foster colonization the settlers were to be assigned lands, and they were granted temporary reductions of and exemptions from certain taxes and duties. Portions of stipulated royal revenues were to be assigned to the construction of public works and hospitals and for the maintenance of clergy and churches until the Church was formally established in the province. License to enslave natives who refused to accept Castilian dominion and Christianity after being

PATIO, THE *MERCADO*, CHICHEN ITZA
The *Mercado* is one of the structures which form the southwestern side of the Group of the Thousand Columns

duly "required" was given. No persons excluded by law, such as heretics and converted Jews (*conversos*) and Moors (*moriscos*), were to be taken to the Indies.

General ordinances promulgated by the sovereign on November 17, 1526, to regulate captains and officials in the conduct of conquest and colonization and to protect the Indians and advance their welfare and Christianization were written into the *capitulacion*. These ordinances provided that the natives should be treated as free vassals of the Crown, that the legal *requerimiento*, or "requirement," that they accept Castilian dominion and Christianity should be duly notified to them through interpreters and that war should be made only in self-defence and against natives who rejected the "requirement" and offered resistance, that only such natives as offered resistance could legally be enslaved, that the natives should not against their will be forced to labor for private persons and that those who voluntarily agreed to work should be duly paid, that the property of the Indians be respected and that trade be conducted justly, and that the natives should be indoctrinated in the Faith, protected, treated well and raised to a higher level of culture. Each expedition of discovery, conquest and trade was to include two qualified members of the secular or regular clergy. These clergy were charged with the task of converting and protecting the Indians, and war, enslavement and the partition of natives in *repartimiento* and their assignment in *encomienda* were to be carried out only with their counsel and consent. They were to report the entire course of conquest and colonization to the Council of the Indies and were to make known to that body all infractions of law and mistreatment of and injustices to the natives, that proper action might be taken. They were also to provide a good example to both colonists and Indians. The *Audi-*

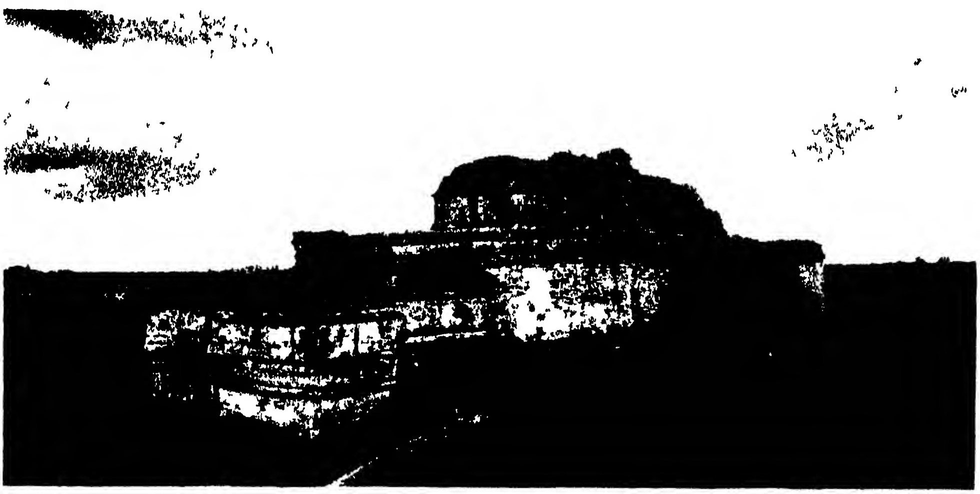


THE TEMPLE OF THE WARRIORS, CHICHEN ITZA
This temple was erected during the period of Mexican influence, and is an excellent example of the late architecture of that era The colonnade in front of the pyramid is projected a considerable distance to the right, and this extension and the colonnade at the side of the pyramid form the northwestern and northeastern sides of the great court known as the Group of the Thousand Columns Other structures extend along the other two sides The excavation and reconstruction were carried out by the Carnegie Institution of Washington

encia of Santo Domingo also was to report to the Council of the Indies all cases of injustice toward the natives, with recommendation of punishment Captains and officials who acted contrary to the more important provisions of the ordinances were to be deprived of office and property

In this document the sovereign proclaimed his motives in the following words

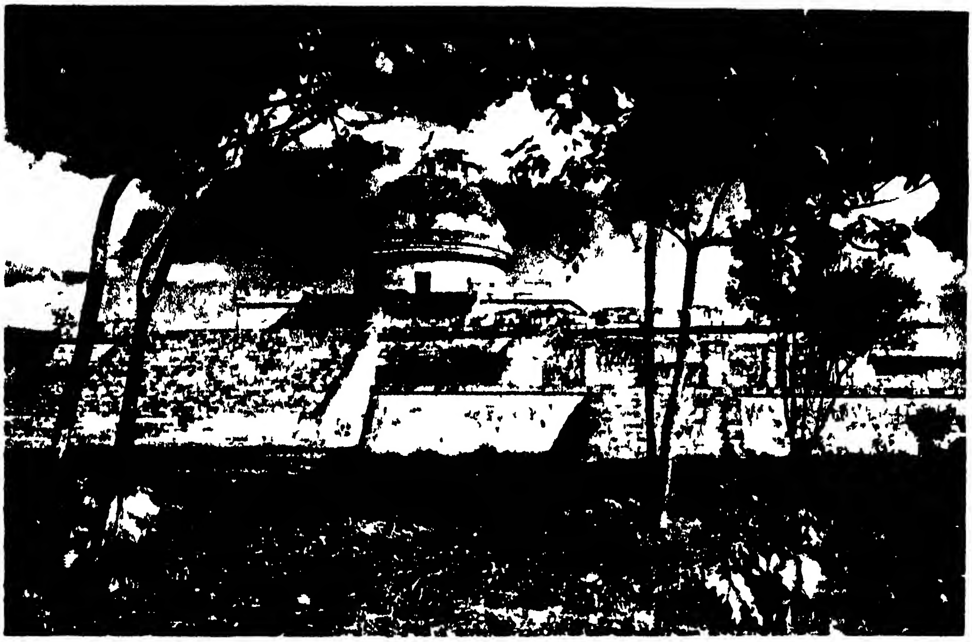
it is Our principal intent and desire to draw the said Indians to true knowledge of God Our Lord and of His Holy Faith through its preaching and through the example of properly endowed [clergy] in rendering them good



THE *CASA DE MONJAS*, CHICHEN ITZA
The *Casa de Monjas*, one of the most massive of the buildings of Chichen Itzá, is an example of construction at various levels Usually Maya structures were placed upon truncated pyramids This structure was erected in the pre Mexican period, and consequently is Maya architecturally

works and according them good treatment , without offering them violence, oppression, harm, or ill in any manner, either in person or property

To prepare for what follows, it is perhaps necessary to summarize the course of the conquest of Yucatan The conquest, which was begun in 1527 and was concluded by 1545, can be divided into three phases The first is that from the autumn of 1527 to 1529, during which the *Adelantado,* having organized a relatively large and well-equipped expedition at Seville, established himself on the east coast and sought to reduce and colonize the peninsula from that quarter Losses through disease and warfare and the realization that a comparatively large force would be required caused him to proceed to New Spain to secure further men and organize a new expedition While in New Spain, Montejo altered his plans, and securing appointment as *alcalde mayor* of Tabasco, he established that province as a rear base for the conquest of Yucatan, recalling his forces from the east coast With these developments the second phase of the conquest began, a phase which lasted from 1529 to 1534 or 1535 Completing the pacification of Tabasco, Montejo passed to Campeche, where he founded a town which was to serve as a center for the reduction of the peninsula proper This phase ended in complete failure as a result of a combination of factors, the most important of which were the stubborn resistance of the Maya of the eastern, central and southern provinces and dissatisfaction among the soldier-colonists with the lack of gold, silver and other wealth Discontent was brought to a climax by news of the conquest of Peru and its incredible riches, which, at a time when



THE *CARACOL*, CHICHEN ITZA
The *Caracol*, one of the most outstanding examples of circular construction in the New World, was built in stages, and includes both Mayan and Mexican elements The circular aspects of the structure are Mexican, and may have been erected shortly after the Mexican invasion The structure was restored by the Carnegie Institution of Washington

the colony had at length been firmly grounded from the military point of view, caused large numbers of men to desert the province in the desire to reach more promising fields With a steadily decreasing number of soldier-colonists, and faced by large numbers of hostile, or potentially hostile Indians, the *Adelantado,* despite his efforts to make it possible to

THE BALL COURT, CHICHEN ITZA
Ball courts are found throughout Middle America, that of Chichen Itzá being perhaps the largest and most impressive In these courts *pok-ta pok* was played, a game in which the players sought to cause a rubber ball to pass through stone rings high on the two parallel walls of the court, midway between the ends The players struck the ball, which was sometimes as much as a foot in diameter, with their hips and knees, but were not permitted to employ their hands and feet

remain, was forced to abandon the region Yucatan could have been permanently settled at this time had the men who composed the forces of the *Adelantado* been of a truly colonizing type

Upon abandoning Yucatan the *Adelantado* passed to Mexico, placing his natural son Francisco in the government of Tabasco Appointed governor of Honduras-Higueras by the Crown and assuming this office in 1537, he was until 1544 engaged in the pacification and administration of that province, of which he is the true conqueror, and in the government of Chiapas, and he did not return to Yucatan until the close of 1546 The final phase of the conquest of Yucatan, extending from about 1540 to 1545, was carried to a successful conclusion under authority of the *Adelantado* by Francisco de Montejo the Younger, Francisco de Montejo, the nephew of the former, and Gaspar and Melchor Pacheco The resistance of those of the Maya who refused to accept Castilian dominion was overcome after several years of hard fighting, and San Francisco de Campeche, Mérida, the capital city, Valladolid and Salamanca de Bacalar were founded in rapid succession A final desperate effort of the Maya of the eastern, central and southern provinces to drive the invaders from their lands late in 1546 was crushed, and henceforth the Castilians, now in considerable numbers and of a truly colonizing type, were secure in possession of the peninsula

The *Adelantado*, who came of a family of the lesser Castilian nobility and who had served in Darien and Cuba, had been a captain under Juan de Grijalva and under Cortés in the earliest stages of the conquest of Mexico, and had represented the latter and New Spain at the court, was a man of wide vision, comprehension and moderation, a loyal servant of the Crown and an able administrator He sought throughout to achieve the aims and policies of the Crown with regard to conquest and colonization, with which he was in full accord From the first, complying with royal ordinances and laws and the provisions of his patent, he directed his efforts toward permanent colonization and the political

and economic development of the regions over which he was given authority, and he sought to protect the natives and further their well-being and Christianization At the same time, he was ambitious and desired power, position and wealth, as did all the great captains who brought the Indies under the dominion of the sovereigns of Castile. Montejo the Younger and Montejo the Nephew were of the same basic character as the *Adelantado,* shared his aims and objectives and, as principal lieutenants, applied his policies They were, moreover, capable soldiers and, like the *Adelantado,* able in administration The characters of the *Adelantado,* his son and his nephew, it scarcely need be pointed out, exercised an important influence on the course of conquest and colonization

The policies placed in effect by Montejo throughout his career are perhaps most readily delineated through summarizing the instructions for the conquest of Yucatan given by him to his son in 1540 on the eve of the final pacification and settlement of the peninsula In these instructions the *Adelantado* provided as follows

(1) That Montejo the Younger assure that the colonists live as true Christians

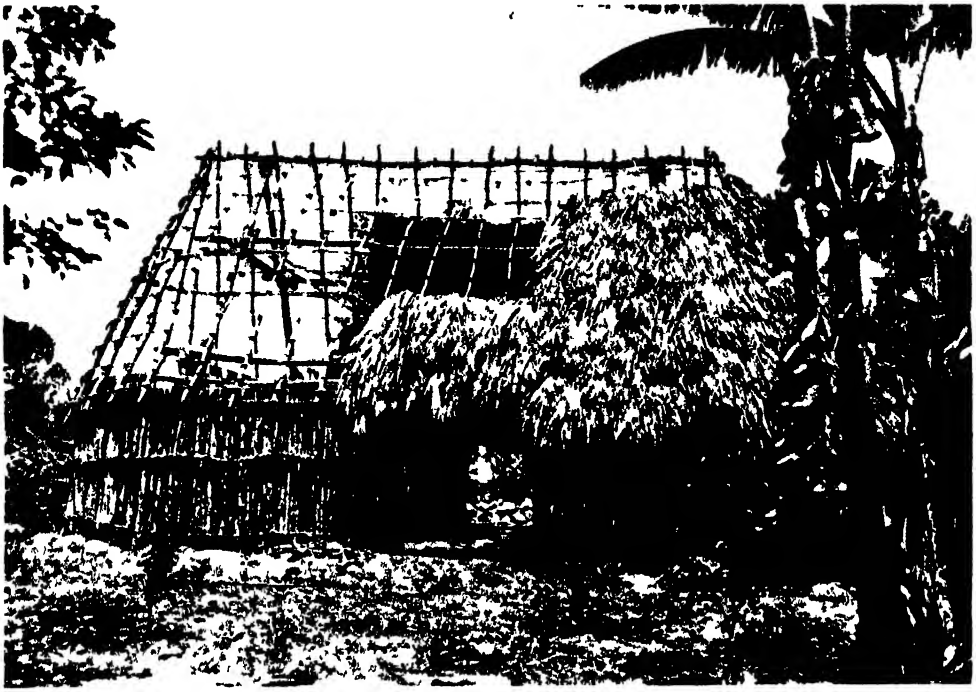
(2) That upon arriving at the town of San Pedro, the advance base which had been established at Champotón, he should determine whether harm had been offered to the natives of the latter place, and that he should restore all property which might have been taken from them and free all who might have been illegally enslaved

(3) That, because of the aid and support which they had given the Spaniards, the natives of Champotón should be exempt from all labor

(4) That he should pass to Campeche, taking with him principal persons, or *principales,* of Champotón, where he should call together the lords of the area and inform them "how you go to people that land in name of His Majesty and to instruct them in the matters of our Holy Faith and that those who do not wish to

CALAKMUL, STELA 52

For many centuries the Maya erected stelae in their cities to record exact dates, those at Quirigua and Copan being exceptionally large On these stelae were carved glyphs and, frequently, life size and highly ornate human figures, perhaps of contemporary rulers or priests The date recorded on the stela pictured here is 9 15 0 0 0 4 Ahau 13 Yax, or August 22, 731 (A D), according to the Goodman Thompson correlation of Maya chronology with the Christian calendar The Maya early developed mathematics to a high degree, and independently evolved the conception of zero and place numeration, having 20 digits They were able to make extremely accurate astronomical calculations



PRESENT-DAY MAYA HOUSE AT VALLADOLID
Roofs are invariably formed of a framework of poles covered with thatch The floors are of mud

come to knowledge of God and obedience of His Majesty and those who do are to be well favored and protected and held in justice"

(5) That, accompanied by *principales* of Campeche and two of Champotón, he should enter the province of Acanul, taking great care that his forces offer no harm or ill-treatment to the Indians of that province, since they had always been at peace with the Spaniards and had desired that they settle among them

(6) That in the province of Acanul he summon a certain lord, Chan Kan, a friend of the Christians who had aided them in time of war, who was to be well received, thanked for the good will which he had displayed, and kept with the Spanish forces as an ally

(7) That he convoke the lords of the province of Acanul and inform them that they might have peace or war as they themselves determined and that if they came in peace they would be well treated and favored If the native lords did not answer the summons, the formal *requerimiento* was to be published, as provided by the Crown, and should this be rejected war was to be made on them In case war became necessary, it was to be conducted with as little harm as possible to both Spaniards and natives and in entire conformance with royal ordinances

(8) That a city, which was to be the principal one of Yucatan, be founded at the town of T-hó if it appeared that the district was favorable for settlement Efforts were to be made to win to peace the natives of the area in which the city was to be founded, but war was to be made on those who did not accept Castilian dominion

(9) That upon the pacification of the provinces which were to constitute the district of the city, these were to be divided in *repartimiento,* according to prac-

tice, and that this *repartimiento* was to be made among not less than one hundred citizens, for, since the area was large and heavily peopled, a large number of *vecinos* was necessary for the subjection of the Indians and the maintenance of control

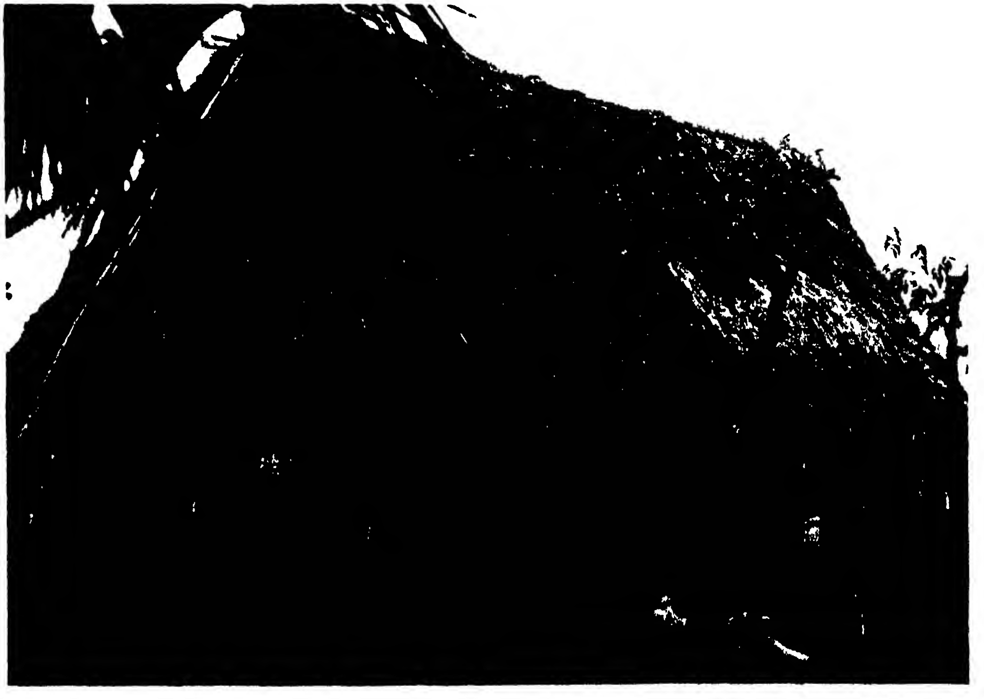
(10) That the *repartimiento* be based on a general visitation of the conquered provinces and that after the number of towns and population had been ascertained *encomiendas* were to be assigned to the *conquistadores* in the name of the Crown in accord with the quality and services of those concerned

(11) That, after the founding of the city, Montejo the Younger strive to have all the colonists develop agriculture and industry, he himself giving the example, and that roads be opened to Campeche, to the north coast and to principal towns

(12) That the Indians be well treated, brought to knowledge of the Faith and under the dominion of the Crown, and drawn from their errors and evil practices

All these things were to be done "placing God Our Lord before, and in service of His Majesty, for the welfare of the land, and in the fulfillment of justice "

The great conquests in the Indies were made at no direct cost to the Crown They were achieved by the greater *conquistadores* upon their own initiative and at their own expense under specific authorization from the sovereign, granted in patents or, as in the cases of Cortés in Mexico and Alvarado, as a lieutenant of



PRESENT-DAY MAYA HOUSE AT CHAN KOM

The walls of the houses may be of frames formed of poles tied together with vines or other materials, sometimes covered with thatch or plastered with mud to render them more substantial, the mud usually being whitewashed with lime Or they may be a combination of low walls of stone and poles which extend to the roof In pre Columbian times the common people lived in the same types of houses as those illustrated, as is indicated by Maya codices, mural decorations and elements of construction found in certain of the great buildings

the former, in Guatemala, in the name of the Crown, and with *post facto* recognition Those delegated authority to conquer and colonize designated areas financed and organized the expeditions for such purposes and in compensation were assigned revenues, privileges, lands and offices in the regions concerned In their efforts the great *conquistadores* incurred heavy expenses The expedition of 1527 organized by Montejo cost some 28,000 *castellanos*, secured by sale of inherited property, loans and funds supplied by his wife, and the Tabasco expedition of 1529 led to the expenditure of 12,000 *castellanos* more Montejo's later efforts in Honduras-Higueras and Yucatan caused further and continued expenses, which were met only in part through revenues from the *encomiendas*, mines and land holdings which he acquired in Mexico, Tabasco, Honduras-Higueras, Chiapas and Yucatan The *Adelantado* also came to an agreement with Juan de Lerma, a relatively wealthy merchant of Mexico, who, from about 1529 to about 1540, gave him material financial assistance At the time of his death he was still some 30,000 *castellanos* in debt, despite his estates and holdings He never received the four per cent of the revenues of Yucatan as provided in his patent, and, indeed, it was not until he was close to the end of his career that the province was in a stabilized condition in which fixed revenues were forthcoming Even then the *encomiendas* he held were removed from him under the New Laws of 1542–1543 The salaries and monetary grants received from the Crown in connection with offices held were always inadequate Montejo the Younger and Montejo the Nephew in like manner financed the major efforts of conquest and colonization which they conducted as lieutenants of the *Adelantado* and likewise incurred indebtedness

Those who took service under the greater *conquistadores* also bore their own expenses with respect to arms, horses, equipment and sustenance Certain of the more important, as subordinate captains, raised companies and groups which they themselves equipped The conquest of the southern provinces of Yucatan, Uaymil and Chetemal, by the Pachecos under authority of the *Adelantado* is an important example of such practice Individual *conquistadores* also frequently brought with them squires and servants Arms, supplies, horses and equipment, it should be pointed out, were normally extremely costly in the Indies The soldier-colonists consequently, as well as the great captains, incurred heavy expenses and indebtedness

Both the greater and the lesser *conquistadores* looked to the conquered lands and their peoples to afford compensation for the expenses which they incurred and the hardships and dangers which they underwent and to give recompense for the trials and uncertainties of colonization, and the Crown in granting or tacitly authorizing such reward achieved its purposes at no direct cost to the royal coffers

The great *conquistadores* desired to achieve for themselves a position of maximum authority and influence and to obtain vested interests which should be based on the powers and privileges granted by the Crown and on their own achievements The sovereigns, despite having in patents granted extensive authority and privileges to these individuals for the achievement of conquest and initial colonization, were determined to establish royal absolutism in its fullest sense in the New World Consequently, to guard against the appearance of powerful vassals who might prove difficult to control and react detrimentally to their authority, after conquest and initial colonization had been carried out, they limited, restricted and revoked the powers and privileges which had been given and created a system of government which,

MAYA MEN AND WOMEN

Physically the Maya are short, thick set and muscular, with relatively long arms and short legs They are pronouncedly brachycephalic The skin varies in color from light to dark brown The upper jaw tends to be prognathous and the chin retreating Eye slits are horizontal or some what slanted, and the typical nose is prominent, high bridged and quite curved in outline The eyes are black and the hair is black, straight and coarse As a race the Maya are characterized by pride, dignity and reserve They are an extraordinarily cleanly people In the picture women are wearing the white cotton *huipil*, which has been their dress from pre Spanish times

based on Castilian forms, depended directly and absolutely upon themselves Columbus and Cortés had been shorn of real authority in accord with this policy, being permitted to retain only empty honors, and the *Adelantado* Montejo was dealt with in similar fashion

Montejo early conceived the project of uniting under his authority as *Adelantado* the entire area from the western limits of Tabasco and Chiapas to and including Honduras-Higueras, with a corridor extending to the South Sea at the Bahía de Fonseca This area was to constitute the *Adelantamiento* of Yucatan, the limits of which had been entirely undetermined in the *capitulación* of 1526 The career of Montejo in many respects centers about his attempts to achieve this great aim Although it appeared possible of attainment at the outset, it was an objective which ran directly counter to royal policy with respect to government, and he inevitably failed

In 1529, when on the point of passing from New Spain to Tabasco, the *Adelantado* first declared his broad territorial claims to the Crown, and in 1533, when permanent colonization of Yucatan appeared assured, he petitioned the sovereign that the area from the western limits of Tabasco and Chiapas to the Río de Ulúa be declared to constitute the *Adelantamiento*, maintaining that it was a geographic, ethnic and linguistic unit. The sovereign did not grant the petition

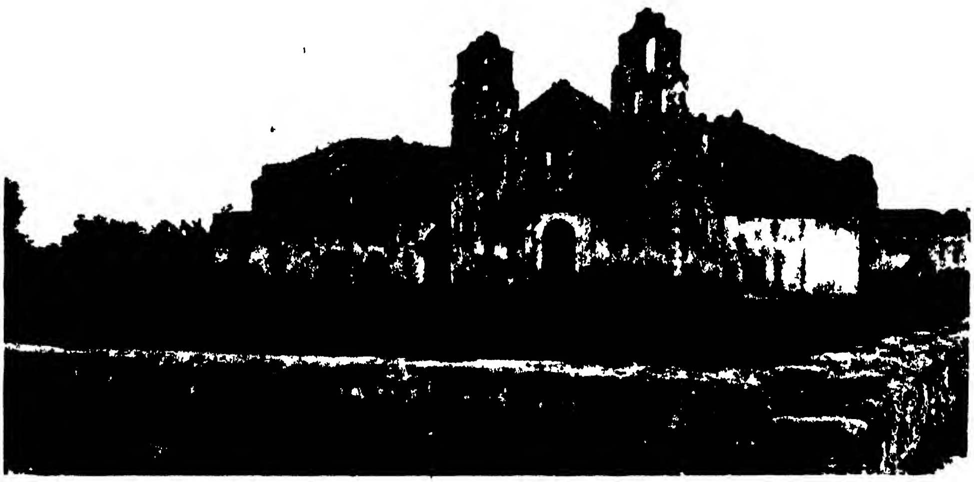
THE *CASA DE MONTEJO*, MERIDA
The construction was begun by the *Adelantado* shortly after the completion of the conquest

of 1533 as such, but nevertheless in that year named Montejo royal governor of the region from the western limits of Tabasco to the Río de Ulúa, and later appointed him governor and captain general of Honduras-Higueras and united that province and Yucatan into an administrative unit under his authority. It is to be noted, however, that the position of Montejo as *Adelantado* applied only with respect to Yucatan proper, although pending final determination he was doubtless encouraged to believe that the lands beyond Yucatan, which had already come to connote only the peninsula, would later be declared by the Crown to be territory of the *Adelantamiento*. Moreover, it is to be borne in mind that when he assumed the governorship of Honduras-Higueras in 1537, Montejo had temporarily abandoned Yucatan and it was not until that year that Montejo the Younger took the first steps toward the reconquest. Pedro de Alvarado, Governor and Captain General of Guatemala, who possessed claims on the governorship of Honduras-Higueras and who at the moment enjoyed great royal favor, in 1539 forced Montejo to relinquish to him the governorship of Honduras-Higueras in return for that of Chiapas. This transfer was approved by the Crown. Upon the death of Alvarado, the *cabildos* of Honduras-Higueras in 1542 recalled Montejo as governor, and, after a confused jurisdictional controversy involving the *Audiencias* of Santo Domingo and Mexico, which had named governors to administer the province, his authority was confirmed in 1543 as a result of support given him by the former body. Meanwhile, Montejo the Younger, who since the abandonment of the peninsula had governed Tabasco as the lieutenant of his father, and Montejo the Nephew had carried forward, under the authority of the *Adelantado*, the final conquest and colonization of Yucatan. The position of Montejo from 1542 to 1544 was consequently extremely involved. He was, under separate appointments, at one and the same time, *Adelantado*, Governor and Captain General of Yucatan, Governor of the area between the

WOMAN GRINDING MAIZE
The great staple of all the aborigines of the New World. This method of grinding maize, employing the stone *metate* and stone roller, has been used by the natives for many centuries

western limits of Tabasco and the Río de Ulúa, and Governor and Captain General of Honduras-Higueras and of Chiapas, and thus, as the result of a most intricate chain of circumstances, governed virtually the entire area which he had striven to erect into the *Adelantamiento* of Yucatan. He remained, notwithstanding, *Adelantado* of Yucatan, that is, of the territory of the peninsula, alone, and the Crown had not extended the territories of the *Adelantamiento*.

September 13, 1543, the Crown removed Montejo from all authority over Honduras-Higueras and Chiapas, and in May of 1544, upon the actual establishment of the *Audiencia*, of which his son-in-law, Alonso Maldonado, had been appointed president, he relinquished office. Authority over the area between the western limits of Tabasco and the Río de Ulúa was then taken from him, although he was permitted to govern Tabasco some time longer. Moreover, under the aegis



CHURCH OF SAN FRANCISCO AT MANI

Illustrating ecclesiastical architecture in an important Indian town. It was in the square in front of this church that Bishop Diego de Landa held his famous auto da fe in 1562, when 27 hieroglyphic manuscripts are said to have been burned.

In the interim the establishment of royal absolute government, in accord with Crown policy, had progressed throughout the Indies. The *Audiencia* of los Confines, later known as that of Guatemala, was created by one of the provisions of the New Laws to govern Guatemala, Honduras-Higueras, Chiapas, San Salvador and the other provinces of Central America, and Yucatan, hitherto within the district of the *Audiencia* of Mexico, was placed under its superior authority in judicial matters. By *cédulas* of

of Bartolomé de las Casas, the Dominican Order had secured authority from the Crown to reduce by peaceful means the region of Tezulutlán, which was within territory which had been placed under the government of Montejo. All Spaniards other than friars were excluded from the region, which came to be known as Vera Paz. The district concerned, consequently, had been removed from the jurisdiction of the *Adelantado*. In 1547 Montejo sought to conquer and settle the general area of the Gulfo Dulce and des-

patched a large expedition which founded the town of Nueva Sevilla The Dominicans immediately protested that the lands assigned to them were being invaded and their work destroyed, and they were supported by the *Audiencia* of los Confines, which, now under the presidency of Alonso López de Cerrato, an enemy of the *Adelantado,* also added protests of its own The Crown ordered the evacuation of the area by Montejo, who had no alternative than to comply

Upon the replacement of Maldonado in the presidency of the *Audiencia* of los Confines by Cerrato, the *Adelantado* was, under authorization of the Crown, removed from the governorship of Tabasco, despite his objections and initial refusal to recognize the authority of the *Audiencia* to take such action At length, in 1549, as the result of charges concerning misgovernment, defiance of royal authority and other matters presented from many sources, among which was the *Audiencia* of los Confines, the Crown caused Montejo to be removed from office in Yucatan His son and his nephew were at the same time stripped of authority. Montejo protested each successive removal from authority step by step, basing his claims on his *capitulación* and royal appointments, but to no avail. In a final attempt to regain his lost position he proceeded to Castile in 1551 to plead his cause directly before the Crown There he died in 1553, at the age of about eighty After the removal of Montejo from office, Yucatan passed directly under the administration of the normal agencies of royal government

The Montejos, it should be noted, while in authority maintained firm control of the government of Yucatan in all its aspects, even to the extent of controlling the municipal councils, or *cabildos,* and they closely determined all the activities of the province This close control aroused opposition on the part of a certain group of the colonists, who desired that the *cabildos* exercise a considerable measure of independence in local affairs in accord with Castilian tradition

(*To be concluded*)

HUMAN PSYCHOLOGY AND SOME THINGS THAT FISHES DO

By Professor F. B. SUMNER
SCRIPPS INSTITUTION OF OCEANOGRAPHY

LET me, in my opening sentence, disclaim any pretence to be more than a dilettant in the field of psychology. However, I do at least claim to be a dilettant in this field, and as such I feel warranted in drawing some psychological analogies in discussing certain problems of fish physiology. Analogies may, of course, be illuminating or confusing, depending upon the phenomena under comparison. So far as the analogies may serve to emphasize points of resemblance which are really fundamental, they may be valuable clues to further discovery

Despite the scorn for "introspection" on the part of some of those who call themselves "behaviorists," it would be difficult to investigate the phenomena of sense-perception in man without reference to what the subject says that he perceives He tells us, for example, what color an object seems to him to have, whether this object appears to be larger than that, this light brighter than that or this sound louder than that The subject's reports to us doubtless constitute a part of his "behavior" in the presence of these stimuli, but his reports would not be very illuminating to us if they were not expressed in terms of inner experience of a kind which duplicates inner experience of our own

Unfortunately, we are unable to put questions, or at least verbal ones, to our fishes, with any reasonable expectation of receiving replies. But the animals are none the less able to inform us, to a certain extent, regarding their sense impressions. Needless to say, a fish's replies to our questions are given in physiological or behavioristic terms, with no mention of the creature's inner life. It is common sense, rather than scientific experiment, which leads us to believe that the fish is not a mere unconscious mechanism

Some cases have interested me of late in which the quantitative relations between sensory stimuli and the physiological responses of fishes seem to be closely similar to those known to hold between these same stimuli and our own perceptions of them And the correspondence in these cases is sufficiently striking to suggest that it depends upon essential similarities in the reactions of living matter in general.

Analogies of this sort may be of equal interest to the experimental psychologist and physiologist The psychologist is vitally interested in the physiological concomitants of mental processes, and the physiologist doubtless profits at times by considering how physiological processes look from the inside. However, let us leave these easy banalities and consider some concrete cases

The first of these cases is one which I have already discussed more than once in the past[1] In fact, my interest in this particular problem dates from the year 1910 I regret that the coherency of my present discussion requires that I shall commence with some facts which are already familiar to most of you. Several groups of animals, and notably the fishes, display the capacity to adapt their shades, colors and even their skin patterns to the surfaces on which they happen to be resting. So important have these phenomena of color change become in the field of experimental biology that

[1] *Jour. Exp Zool.*, 10. 409–505, 1911, *Physiol. Zool*, 2 495–504 (with A B. Keys), 1929; *Biol. Bull*, 65: 266–282, 1933.

their special bibliography must by this time exceed a thousand titles. Our recent symposium on this subject illustrates my point [2]

We now have ample reason for believing that these color changes serve, among other things perhaps, the needs of concealment In order that they may attain this end, it is obvious that the shade assumed by the animal must be constant, or nearly so, upon any given background, regardless of the intensity of the general illumination This because both the animal and its background are equally affected by any change in the source of light. That such is the case, at least among the fishes, has been shown by abundant evidence Under ordinary conditions, it is the shade of the background which influences the shade assumed by the fish. Within broad limits, the intensity of the incident light is found to play a very minor part in the matter Thus the state of the fish's chromatophores is not determined by the absolute amount of light which reaches the animal's eyes, either directly from the source of illumination or by reflection from the background and surrounding objects

Evidence from several sources makes it plain that the chief determining factor involved here is the ratio between the reflected and the incident light This proposition is less simple, perhaps, than at first appears, for we can not credit the fish with any capacity to distinguish reflected from incident light, and to apply the proper correction for the intensity of the latter. On the other hand, the fish may be assumed to recognize differences of position within the visual field, and particularly the difference between up and down The animal's response to the ratio *reflected: direct illumination* may therefore be supposed to resolve itself into a response to the ratio *lower: upper half of the field of vision* Bearing in mind the inversion of the light rays within the eye, we have to do with the ratio of illumination between the upper and lower halves of the retina That such a polarization of the retina, or possibly of corresponding areas within the brain, may actually exist is rendered probable by some experimental evidence [3]

Several investigators, including the writer, have more or less successfully attempted to screen off one half of the field of vision by means of appliances covering the eye. Certain others have reported success in rotating the eyeball on its main axis through an angle of 180° The upshot of these experiments seems to be that illumination of the upper and lower halves of the retina tends to call forth opposite responses on the part of the chromatophore system of the fish Increasing the illumination of the upper half, relative to the lower, results in the paling of the fish; increasing the illumination of the lower half, relative to the upper, results in the animal's darkening Evidence has recently been published, pointing to the existence of an actual morphological differentiation of these regions of the retina which may possibly be related to the physiological differentiation

However, it seems doubtful, even for the fish, whether this problem of the correct perception of shades is fully explained by the simple assumption of a functional dorso-ventrality of the retina That such an assumption would be altogether unwarranted in the case of man is quite certain. For it must be remembered that we encounter this same problem in relation to our own visual perceptions, albeit we humans, or at least those of the male sex, are unable to respond with appropriate changes in our pigmentation

As Professor Woodworth has recently expressed the case:

[2] Am Soc. Zool., Richmond, December 29, 1938.

[3] Sumner, *Biol Bull*, 65: 266–282, 1933, Vilter, *C R de l' Association des Anatomistes*, Marseille, March, 1937, pp 1–14, Butcher, *Jour Exp Zool*, 79 275–297, 1938.

It is a fact of common observation that coal looks black even in sunlight and that chalk looks white even in shadow Yet the light reaching the eye from well-lighted coal is very much stronger than that from shaded chalk The retinal image of the coal is much brighter than that of the chalk, under the conditions, and the stimulus received from the coal is much more intense One's impression conforms to the object rather than to the stimulus, and he is apt to see no problem here, for if coal is really black why should it not be seen as black in a good light? Not a bad answer, perhaps, but one involving some tacit assumptions that the psychologist would like to make explicit [4]

Thus we have the much-discussed, if poorly named, problem of "color constancy" or, as it has been more technically termed, "phenomenal regression toward the real object"

To continue from Woodworth·

A certain mixture of white lead and lamp black reflects 25 per cent. of the light, its albedo measure is 25 per cent It reflects more light, absolutely, when it receives more, but it always reflects 25 per cent of what it received If it is moved from a weaker to a stronger illumination, or the reverse, the observer still sees it as the same gray (approximately), thus in effect perceiving its reflecting power or albedo We have been perceiving albedo all our lives without knowing it

It is true that this correction for illumination is not always perfect Under experimental conditions, the estimate of albedo is frequently more or less of a compromise between stimulus and objective perception

That our correction for illumination is an act of conscious judgment is as little true for man as for the fish The entire process takes place on the perceptual plane We are influenced by various clues to general illumination, the nature of which has been studied in considerable detail by a number of investigators It is impossible to discuss these clues here, except to say that they are provided by a variety of relations which may obtain among the contents of the visual field No simple geometrical distinctions between upper and lower can be invoked.

If, by any device, the observer is deceived respecting the brightness of the light by which a given object is illuminated, his estimate of its albedo may be enormously in error Black may look white, and white may look black These illusions may be promptly dispelled by the introduction of suitable clues into the visual field, but they return immediately upon the withdrawal of the clues, despite the subject's full awareness of the deception.

Experiments in our laboratory and elsewhere have shown that fishes may be similarly deceived In certain of these experiments,[5] the fish (one of the flounder group) rested upon a strip of clear glass, raised above an underlying gray surface, the latter being illuminated by a source of light invisible to the fish, and thus made to appear lighter than would have been possible if illuminated only by the source of light overhead In these cases, the fish acted as if the substratum had been white, and assumed its maximum degree of pallor. When conditions were reversed, the fish darkened more than its background would have warranted, had the latter been normally illuminated

There is another aspect of these color-change phenomena which finds a highly instructive parallel in the field of experimental psychology Several years ago, we endeavored to determine what quantitative relations might exist between the visual stimuli to which our fishes had been subjected and the resulting effects upon pigmentation It is now well known that prolonged subjection of fishes and amphibia to appropriate backgrounds may bring about very considerable changes in the actual amount of pigment possessed by these animals, in addition to the rapid rearrangement of pigment already present, such as results

[4] "Experimental Psychology," Henry Holt and Company, New York, 1938

[5] Sumner and Keys, *Physiol Zool*, 2 495–504, 1929 Confirmed in some essentials by Pearson, *Ecology*, 11 703–712, 1930.

from briefer exposure to the same stimuli.

In the experiments under consideration, we have employed two methods of evaluating the effects of the stimuli in question upon pigment formation. The first of these was an attempt, thus far only partially successful, to assay the amount of the black pigment, melanin, present in a given lot of experimental fishes[6] The second and more dependable method has consisted in counting the number of melanophores or melanin-containing cells present in a given area of the skin. In the course of these experiments, fishes of three different species have been subjected, on the one hand, to backgrounds of widely different albedo, the source of illumination being constant, on the other hand, to widely different sources of illumination with a constant albedo

In the first type of experiment, the fishes were kept in glass aquaria, which had been painted black, white and two (later three) shades of gray, the specific reflectivity or albedo of each of these backgrounds being determined with approximate accuracy. In experiments of both types, the intensity of illumination from overhead was measured.

To state briefly the results of these experiments, we may say that the albedo of the background was found to be the factor of chief importance in determining the production or loss of melanin. (I speak of *loss* because the decrease of pigment upon a pale background is quite as conspicuous a fact as is its increase upon a dark background)

The intensity of the incident light appears to be influential to a minor degree, at least in some cases. The extent of this latter influence will be the subject-matter of further experiments to be commenced in the near future From the human analogy, we might expect to find such an influence, since the estimation of albedo is not entirely unaffected by the intensity of the illumination.

When the yield of melanin was plotted against the albedo of the background, it was at once evident that there was a consistent negative correlation between the two, the greatest yield being derived from the black-adapted fishes, the least from the white-adapted ones. It was equally evident that this was not a simple linear correlation, such that equal increments of albedo called forth equal decrements of pigment formation The resulting curves looked suspiciously logarithmic, and this suspicion was borne out, for one series at least, when the data were plotted on logarithmic paper

My most recent data, based upon the counting of melanophores, seem to confirm these earlier results very nicely. I think that we are justified, therefore, in concluding provisionally that melanin production (or loss) varies inversely as the logarithm of the albedo of the background This conclusion is subject, of course, to the customary reservations. for the species under consideration, and within the limits of the stimuli here employed

Now I am not one of those who believe that one's scientific respectability demands that he shall express all his results in terms of logarithms In most cases, curves based upon natural numbers mean much more to me But we all meet with occasions when the logarithmic arrangement of one's data is highly illuminating, and I believe that the present case is one of them.

Let us return to the field of experimental psychology As a result of extended studies, E H Weber announced, about a hundred years ago, a generalization which has become famous in the realm of sense-physiology. The generalization was a simple one, and may be stated as follows: If, to a given stimulus S, we must add the value d, in order that the difference shall be just perceived by the subject, we must add not d but 10 d,

[6] Sumner and Doudoroff, *Proc Nat Acad Sci*, 23: 211–219, 1937; 24 459–463, 1938.

if we start with a stimulus ten times as great. In other words, the increments of stimulus must be proportional to the original stimulus, rather than equal to one another, in order to bring about equal increments of sensation. In still other words, the increments of stimulus must be increased in geometrical progression, in order that the increments of sensation shall increase in arithmetical progression Fechner expressed the matter in a simple equation· Sensation = C log Stimulus

The Weber-Fechner law has, of course, been attacked on various grounds, logical and factual On the former side, it is easy to see that just perceptible increments of sensation are not necessarily equal increments, on the latter, it is now well known that the "law" holds only for stimuli of medium intensity, but breaks down at both extremes. However, for present purposes we are not interested in such questions as the absolute magnitudes of sensations, while the generalization does hold fairly well throughout a wide range of intensities

Thus far, then, we seem to have encountered two interesting points of agreement between our own sensory physiology and that of the fish In the first place, we are both able to recognize the albedo of surrounding objects, regardless of their absolute illumination,[7] in the second place, the relation between sensation and stimulus seems to be, for both of us, a logarithmic one I am quite aware that examples of the Weber-Fechner rule have been previously reported from the field of sub-human physiology, though none, so far as I know, in the realm of pigment formation. Endeavors have been made to interpret these relations on the basis of assumed physiological processes, but I believe that no proposed hypothesis has met with general acceptance.

Let us put some further questions to our fish, this time questions which have nothing to do with its sense of vision. If we raise the temperature of the fish's bath by ten degrees C, its consumption of oxygen will increase about three-fold; if we lower the temperature, a corresponding decrease will occur.[8] These facts, it is true, do not parallel what takes place when we subject ourselves to such temperature changes Quite the reverse In general, warming our environment lowers our metabolic rate, while cooling raises it This, of course, is not due to any radical difference in the effects of temperature upon the protoplasm of cold-blooded and warm-blooded animals. It merely results from the possession by the latter of a heat-regulating mechanism which compensates for changes in the environment.

The parallel which I wish to draw is of another sort When the fish is placed in warm water, its respiratory metabolism rises rather promptly to a maximum, and then gradually falls, though it never falls to a level as low as existed before the transfer I must hasten to add that the term "never" applies here only to laboratory experiments, lasting a few months at most The metabolic rate of fishes living in naturally warm waters—in warm springs for example—is a subject which could be investigated very profitably But whether it is complete or only partial, this physiological adaptation to higher temperatures is a process which can be readily observed and measured[9]

Now let the human experimenter plunge his own hand into water considerably warmer than his skin temperature at that moment He experiences a sensation which we are accustomed to call the sensation of warmth, and this, at the outset, may be very pronounced But let him leave his hand in this warm water for a short time, and the intensity of the

[7] See also Burkamp (*Zeits der Psychol und Physiol. der Sinnesorgane*, 55 Bd, 1923, S. 133–170), whose experiments furnish evidence of a quite different sort for the perception of albedo by fishes.

[8] Wells, *Physiol. Zool*, 8· 196–227, 1935

[9] Sumner and Doudoroff, *Biol. Bull*, 74 403–429, 1938

sensation diminishes rather rapidly. He, too, undergoes an adaptive change, such that the "physiological zero" or neutral point of sensation may be shifted by many degrees, and this within a few minutes' time

Thus, the phenomena of temperature adaptation, in these two cases, present a very similar picture, although in one case we have to do with changes in oxygen consumption, in the other with sensory experience We have, in each case, an abrupt rise in magnitude, followed by a more gradual fall However, we are able to point out more striking similarities between these two sets of phenomena

There is one type of experiment which we have performed many times upon fishes, and with consistently uniform results.[10] This is to transfer two lots of specimens which have sojourned some days or weeks at high and low temperatures, respectively, to a common intermediate temperature, and to determine their relative rates of metabolism after varying intervals There is at first a complete reversal of the former relations, the fishes from the warmer water now having a much lower metabolic rate than those from the colder. After the lapse of a few days, however, these differences are obliterated

Compare these findings with a classical experiment of Weber's, which most of us have doubtless performed Let us immerse our two hands in warm and cold water, respectively, then, after a minute or two, plunge them both into water of intermediate temperature The latter will feel at the same time cold to the one hand, and warm to the other, a reversal exactly comparable to that experienced by the fishes. Within a fraction of a minute, these differences will have vanished

The relative rate of these adaptations in man and in the fish might seem to throw them into quite different categories Those in man are to be measured in minutes or even seconds, and seem to be primarily phenomena of the nervous system Those in the fish, on the contrary, cover days or weeks They are very questionably to be ascribed to the nervous system, despite the far slower tempo of nervous processes in a cold-blooded animal Nevertheless, both are excellent examples of physiological temperature adaptation, and it hardly seems likely that the analogy between them is entirely superficial The various phenomena of contrast and negative after-effects are familiar both in physiology and psychology, and the physiological mechanisms which underlie them are not altogether unknown

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Thus far, however, we have been traveling in waters which have been sufficiently charted to give us at least a comfortable sense of security We could see enough beacons and lighthouses in various directions to keep us from being stranded on the shoals or dashed to pieces on the rocks We might never have reached the promised land, but at least we were never in danger of shipwreck

I am going to ask you now to sail with me upon a cruise of reckless adventure, with nothing but dead-reckoning to guide our course Your captain is painfully inexperienced and possibly even subject to hallucinations Also, the mate tells me that the rudder has been lost We shall embark from the harbor of solid fact, and end, perhaps, in the fog of phantasy. Are you ready?

Let us commence with one of the more spectacular performances of fishes I refer to the spawning migrations of the salmon.[11] The story has often been told, and you are all doubtless more or less familiar with it Perhaps the oft-repeated assertions of certain critics may have led you to believe that the essential

[10] Wells, *Biol Bull*, 69 361–367, 1935, Sumner and Wells, *ibid*, 368–378; Sumner and Doudoroff, *Biol. Bull*, 74. 403–429, 1938

[11] Since a comprehensive review of the literature of this field has recently been prepared for *The Quarterly Review of Biology* by Mr. Bradley Scheer, I have not thought it worth while to cite references here

features of this narrative are still in doubt. While I altogether lack personal experience in this field, I think that a careful reading of the evidence will convince most biologists of the validity of the so-called "home-stream theory."

The amount of sound observation and well-planned experimentation upon which this theory is based is very great; and while certain inevitable gaps exist in the continuity of the direct evidence, there appears to be considerable indirect evidence which serves to fill in these gaps. On the other hand, such limited negative evidence as has been published would seem to apply only to particular streams or particular local populations of salmon, and it certainly does not invalidate the far larger mass of positive evidence. I shall speak chiefly of the Pacific salmon, since our best evidence has been derived from these.

Here, then, are some of the facts. Young of several species of Pacific salmon have been marked in lots of many thousands at a time and liberated at various points in a number of the river systems of British Columbia and our own Pacific states. Many of these individuals have been recovered upon their return from the ocean to spawn several years later. With insignificant exceptions, such fishes have been taken in the river system in which they were planted, the exceptions relating to streams in the immediate vicinity. Moreover, they were taken very preponderantly in the same tributary in which they were planted.

"The most striking instance of this return to the home-stream," say Rich and Holmes,[12] "is that to Spring Creek. This stream is so extremely small that it is difficult to see how the salmon could find it at all, and yet 82 of the fish marked here were recaptured here as adults, while only 4 were taken in other spawning tributaries."

However, this specificity, in relation to the particular tributary, is not always as precise as in the case cited. It seems to depend, in some measure, upon how long the young fish stays in the stream before its migration to the sea. One highly important fact must be stressed here. Transplantation experiments with young bred in the hatchery have shown that it is not necessarily the home-stream of the parents to which the spawning adult returns. It returns to the stream in which it spent its own early life after hatching.

The facts thus far stated would not be so difficult of explanation if it could be assumed that the marked fish, after its descent to the ocean, never ventured far from the mouth of its home stream, but remained within the latter's zone of influence until the spawning instinct prompted it to seek fresh water again. Even then, we should be left with some tough problems to solve. Unfortunately, no such assumption is warranted. Many of the marked fishes have been trapped at distances of hundreds of miles from the river's mouth.

Certain writers, apparently wishing to save their faith in the simplicity of biological phenomena, have contended that all such specimens must necessarily be "strays," which could never have made the home journey. But such a claim is purely gratuitous. Salmon which have been tagged in the ocean as adults, as far away as Queen Charlotte Island, more than 600 miles distant, are known to have entered the Columbia River to spawn.

Moreover, the proportion of these "strays," in some experiments with the Atlantic salmon, is known to have reached as high a figure as 30 per cent. of those recovered, certainly an unexpectedly high proportion of biological wastage, if the contention of these critics be granted. And again, one may ask, why should not these supposed stragglers, under the urge of the spawning instinct, seek fresh water and attain their end in the nearest available river? Apparently, this never happens.

Further important indirect evidence

12 *Bulletin of the U. S. Bureau of Fisheries*, 44: 215–264, 1929.

is derived from a study of the scales and some other characters of the salmon, which indicate that the fishes of different rivers, even those belonging to the same species, exhibit recognizable racial differences. It is significant that mixed populations, comprising a number of these local races, have been found on oceanic feeding-grounds, far from these various home-streams It would certainly be difficult to account for the maintenance of such races, except on the supposition that they segregate themselves and travel independently to their respective streams at the time of spawning.

In the present state of our evidence, I think that we can hardly escape the conclusion that the individual salmon commonly returns to spawn in the same river and tributary in which it passed its early life, and this even after the lapse of several years spent in the ocean, and after migration to points which may be hundreds of miles distant

The difficulty of accepting this conclusion results, of course, from the difficulty of accounting for the phenomena concerned. And yet we have difficulties of a similar nature, and perhaps even greater ones, in the now well-known life histories of the American and European species of fresh-water eel Here, the mature fishes, after a life of many years in the fresh-water streams of America and Europe, return to spawn in the region of their nativity in the western Atlantic, in many cases after a journey of several thousand miles But that is not all. The young of these two species, with no parental coaching, except what is conveyed through the genes, reach in time their own proper sides of the Atlantic and ascend the rivers. We will not say the same rivers in which their parents had lived That would seem to be too much to ask of them, though it would be an impossible thing to prove if they actually did it.

The different life-histories of these two species depend in part upon differences in the length of the larval period, that of the European eel lasting about three years to the American's one. And the northeasterly migration of the European larvae is partly passive, being aided by the Atlantic drift Yet neither of these circumstances helps us very far toward an explanation. We must recall that the eggs of the two species are laid in contiguous or even overlapping areas of the ocean and that the young larvae mingle together freely at first throughout a considerable area.

It is true that attempts have been made to force a certain part of these facts into our previously accepted categories and to question the others Writers holding this point of view would account for the return migrations of the salmon as a succession of thermotropic or chemotropic responses One prominent American biologist, for example, has contended that at each fork of the road the fish selects the colder water, while a French writer seems equally convinced that it is the proportion of oxygen which each stream carries that is determinative in the choice. Such suppositions can hardly explain how a number of races may make different selections at the same crossroads.

That the phenomena of salmon migration do not fit into these or any other established physiological categories would seem evident from a brief examination of the data already known. On any theory, we must grant the existence of some sort of organic memories or "engrams," recorded in the nervous systems of the fishes, since the return journey is so largely dependent upon the individual's early history These memories must relate, in some way, to the individual's past experiences of the environment According to our familiar modes of interpretation, they must enable the animal to recognize very specific elements of this environment, to the extent that they are able to trace their early wanderings in reverse. But this would necessitate the supposition that the essential elements of the fish's early environment, and the rela-

tions among these, remain essentially unchanged during the animal's long absence. This plainly can not be the case.

Let us, for example, suppose that the fish "remembers," albeit unconsciously, the quality of the water of its home river and tributary creek, and is able to distinguish this from a great variety of other waters through which the nostalgic creature passes on its return journey to spawn Such a supposition would not be incredible, perhaps, if we could assume that the sought-for water retained its old-time flavor But suppose, as actually happens, that the young fish left the river in the fall, whereas it returned in the spring, when the water temperature was much lower. In such a case, too, the downward migration must have taken place during a period of low water, whereas, at the time of the return journey, the spring freshets had perhaps quadrupled the river's flow, stirred up much silt, aerated the water more thoroughly and in general changed its chemical and physical properties Then, too, forest-fires on the watershed, and changes due to agriculture or to industrial development can not fail to modify the composition of the water from one year to the next These resulting fluctuations in the character of the water of any single river may surely lead to greater differences at times than those which distinguish one river from another.

How, then, can we resolve these directed wanderings of the salmon into a mere succession of thermotropic or chemotropic responses, when there is no constancy in the physical conditions of any part of the travel-route from month to month or year to year? I don't believe that this can be done.

I have spoken of the thermal and chemical senses in this connection, since any other known special senses of the fish may be safely left out of consideration Many persons, particularly those without biological training, are quick to appeal to some unknown "sixth sense" to help us out of such a situation As if most vertebrate animals, fishes included, did not have more than six senses already!

The question in this case is not so much that of discovering some additional sensory mechanism in the fish as it is of finding, or even conceiving of, some hitherto unrecognized mode of physical energy competent to act as a directive stimulus. I think that we are justified in saying that we lack any satisfactory clue to such a directive stimulus at the present time The situation might seem to call for some method of geodetic orientation upon the earth's surface rather than mere guidance by stimuli from successively encountered features of the environment. But orientation in the earth's magnetic field would surely be a wild guess, and guidance by means of the earth's rotational forces would perhaps be an even wilder one And what would you think of me if I should attempt to endow the poor fish with some sort of an integrating mechanism, such as our mathematical friends employ in their calculations—one which would automatically register all the components in the animal's meanderings and come out with the right answer, in spite of everything? Alas, though the fish's anatomy is pretty well known, there doesn't seem to be room anywhere for an integrator

Whatever unknown or unsuspected factors may be operative, however, we may be certain that the animal's recognized senses supplement these and play an important part in the matter, throughout Above all, it should be insisted that this entire range of phenomena lends itself very well to experimental attack. Various hitherto untried experiments suggest themselves, which would go a long way towards clearing up some of the more baffling points

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I am next going to take you on what some of you may regard as a brief trip through the scientific underworld. Before permitting yourselves to be shocked

or indignant, however, I beg of you not to form premature notions of my real meaning

There is still a wide-spread belief, dating from man's earliest past, that we have channels of knowledge independent of our recognized senses. This belief would seem to have all the earmarks of a primitive myth, and I am not prepared to say with full confidence that it is not precisely that However, it is a curious circumstance that evidence for phenomena of this type has been accumulating in our present scientific age, and indeed in the hands of some of the scientists themselves. Experimental methods have been applied, sometimes with every appearance of honesty and intelligence, and results obtained which have seemed conclusive enough to convince men of high standing in their own special fields of science Our great psychologist, William James, for example, unhesitatingly expressed his belief that the "medium" (or her "control") might be "acquainted with facts about the circumstances, and the living and dead relatives and acquaintances, of numberless sitters whom the medium never met before, and of whom she has never heard the names "

One may, of course, cite James as a striking instance of how a brilliant and learned man may allow himself to be woefully deluded, and this may, indeed, prove to be a just appraisal of his case However, I should insist that no one is entitled to offer such an opinion unless he has at least taken the trouble to examine the evidence on which James based his beliefs

As many of you may know, there is a rather steady output at the present time of alleged proofs of the reality of both telepathy and clairvoyance Such claims are not restricted to "swamis" and Gypsy princesses They are being made by men holding chairs in some of our more reputable universities, and they purport to be based upon rigidly experimental procedure. The claims of Professor Rhine, of Duke University, are probably the best known in recent years,[13] but similar results have been announced from various other sources which would ordinarily be calculated to inspire confidence

We are assured, for example, that a certain proportion of the subjects who have been tested in this connection are able to designate cards of a special set considerably more frequently than would result from mere chance guessing. In some of these tests the subject and the experimenter were in different rooms or in different buildings or were even miles apart

Particularly bewildering to us would be admission of the claims of clairvoyance It is alleged that certain of these subjects possess the ability to penetrate the depths of a pack of the experimental cards and to discern, preponderantly at least, the order in which they chance to lie No form of radiant energy would seem competent to reveal to a sentient being the differences of pattern in cards lying at successive levels in a pack, a fraction of a millimeter apart Think what a jumble an x-ray photograph would make of such superimposed patterns!

On the whole, these experiments have every appearance of being conducted honestly, and with a serious endeavor to exclude the numerous opportunities for self-deception Statistically speaking, they would seem to have vastly higher evidential value than we ordinarily demand in an experimental research in biology

Where, then, is the joker in all this? I confess that I do not know It would relieve our minds vastly, of course, if we could accept the most obvious explanation, that of fraud If it is fraud, it has been conducted on a rather large scale, and in some quite unexpected places In

13 "Extra Sensory Perception," Boston, 1934; also articles in *Jour. Parapsychol.*, published by Duke University, Durham, N C.

some of the cases, it must have involved conspiracy on the part of a number of persons Self-deception is another familar mode of explanation, and a far more charitable one, but it is not at all easy to reconcile this with the published accounts of the procedure These are more easily reconcilable with intentional deceit

It is my guess that a large majority of those here present will be content to dismiss the subject with one of these alternative explanations—fraud or self-deception I wish that I could be satisfied with such a ready solution of the problem It is my impression that this type of solution is less acceptable in proportion to one's familiarity with the evidence And in so saying I by no means restrict myself to the evidence of the past few years

Now I can feel—and this without any recourse to telepathy—that some of you are bewailing my folly in giving serious attention to such a thoroughly "screwy" subject before an eminently respectable scientific gathering such as this However, please remember that I came to you primarily as a student of fishes, and that it is the time-honored privilege of one who talks about fishes to depart from conventional notions of credibility Now and then, too, the narrator of fish-stories it able to confound his listeners by showin them that the incredible is true, as witness the homeward migrations of the larval eels, already referred to, or the story which I have just related of the return of the spawning salmon from the ocean to the old swimming hole, in that little creek, hundreds of miles upstream from the river's mouth. But you don't have to take the word of the fish man for the reality of these incredible performances among animals The ornithologist has long told us impossible things about the migrations and homing instinct of birds, and in recent years he has been able to back up his assertions experimentally by the use of the banding method.

Before concluding, I hope that I may be able to dispel any misunderstanding as to what I have been trying to tell you in this last section of my address I am not asserting that any experiments in the field of telepathy and clairvoyance yet stand on the same footing scientifically as those of the salmon-taggers or the bird-banders. Nor do I say, or even imply, that these fishes or birds are guided by any such faculty as that which (*perhaps!*) enables our clairvoyant friends to see through their packs of cards or to filch perceptions at long range from the interior of one another's craniums

My intention, in this last section of my address, is to insist upon the possibility that in both man and some other animals, impressions from the environment may not all be mediated through recognized organs of special sense which are sensitive to recognized modes of chemical or physical stimulation This does not mean that I wish to remove a large and important class of phenomena from the field of natural science There is abundant opportunity for rigidly exact investigation here, both in the case of man and fish And I believe that it is our present duty to settle some of these highly controversial matters by experiment, instead of dogmatically denying them or complacently ignoring them

You may think that these remarks of mine are merely the maunderings of a senescent brain If so, my brain began to senesce many years ago However, it is a popular belief that willingness to entertain strange and unwelcome ideas is a quality of youth rather than of old age and that the real attributes of senescence are bigotry and intolerance to new modes of thought And so I will rest my defense on the plea of extreme youth and throw myself on the mercy of the court.

TIME AND PLACE FACTORS IN EARLY HUMAN EMERGENCE

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THE quality of interest being displayed at the present time in the various problems pertaining to early human history differs in kind and degree from that of any preceding age Although innumerable generations have rendered lip service to the classic admonition "know thyself" —carved by unknown hands above the entrance to Apollo's temple in ancient Delphi and proclaimed by Socrates to be the beginning and the end of the pursuit of knowledge—yet it has remained for the present generation to bring to bear on this central problem of human interest a discipline of factual thinking that is destined to remove the problem, for all time let us hope, from the realm of mere philosophical and metaphysical speculation. This fortunate circumstance, the significance of which it would be difficult to overemphasize, has not come about fortuitously. During a relatively brief period of years, not exceeding two or three decades in certain fields of investigation and hardly more than as many centuries in others, man has acquired a keener sense of reality and a deeper respect for the forces inherent in nature than he has ever had before His growing understanding and confidence in the essential integrity of natural law, including even the laws underlying the mysterious phenomenon of life, are such that in spite of his fumbling efforts to interpret the evidence dealing with his own existence, man nevertheless feels no longer impelled to divorce himself from the rest of nature and ask the intervention of a supernatural order on his behalf

Among the various questions relating to early human history, there are two in particular about which the interpretation of the available evidence has up until now been particularly difficult These are, briefly: (1) *when*, in geological history, did there appear on the scene those unique creatures whose sum-total of physical and mental attributes, so far as we may surmise, entitles them to be considered the earliest members of the human family, (2) *where* on the earth, with due consideration of the paleogeographic alterations in the various land masses involved, did there exist the particular combination of circumstances most likely responsible for the ultimate differentiation of these early hominid forms from the parent Primate stem In brief, today, we are still asking, as thinking man has probably always done, about the when and where as well as the whence of the coming of mankind The significance of *Sinanthropus pekinensis*, the best documented of the early fossil hominids thus far discovered, resides largely in the fact that this primitive form contributes significantly to the answers to these questions

The comparative wealth of *Sinanthropus* fossil remains now available enables human paleontologists to define its distinctive characters and to determine that it represents without doubt the earliest hominid type yet discovered under circumstances conducive to a distinct advance in knowledge concerning many of the special questions involved. Its contribution to the first of the questions mentioned above, namely, that of the time element in early human evolution, resides in the simple but significant fact that the remains in question were found firmly

embedded *in situ* in the undisturbed geological formation of the time during which this creature lived The definite geological age of this formation is amenable to determination in accordance with usual paleontological procedures The fortunate circumstances under which the *Sinanthropus* remains were discovered are in sharp contrast with the considerable uncertainties respecting the geological formations yielding the remains both of *Pithecanthropus* of Java and *Eoanthropus* of England Both these latter finds were recovered from beds of redistributed gravels Therefore, in addition to certain controversial questions relating to these respective finds on morphological grounds, there will always remain a considerable degree of uncertainty regarding their actual geological age.

With regard to the age of man as disclosed by *Sinanthropus,* on the basis of careful study of the stratigraphical and paleontological evidence the Choukoutien fossiliferous deposits containing the remains are assignable to the early stages of the Pleistocene period of geological time If we accept the latest geochronological estimates based on radio-activity determinations, then we must assign to *Sinanthropus* an age approaching very nearly one million years

This figure is of significance chiefly when compared with earlier estimates of the time of human origins, or when considered in relation to either the age of the earth or the estimated span of total life history on the earth Compared to earlier estimates this newly determined age of man is much greater than hitherto assumed. Indeed, the figure is two or three times that given in many present-day treatises dealing with the subject of early man A million years, however, is none too long a time for the significant morphological changes that have taken place in the human organism since *Sinanthropus.* There will perhaps always be a considerable range of variation in expert opinion bearing on the point in question Estimates of the exact age of man will probably always vary as much as from a quarter to a half million years It must be noted, however, that each successive geochronological determination increases rather than decreases the probable duration of the various divisions of the total life period and correspondingly that of man The significant fact is that when compared with either the total age of the earth or the span of life on the earth—ages estimated by the latest radio-activity methods of determination as approximating 2,000,000,000 and 600,000,000 years respectively—then it must be realized that mankind, with barely one million years to his credit, is among the very youngest of the distinctive animal forms inhabiting the earth to-day And when contemplating the various problems besetting the human family, it is well to appreciate the fact that this extreme *youthfulness* of man, which in many respects is his most significant paleontological characteristic, must at the same time be counted his greatest asset

Of slightly different order but of equal interest with that of age is the question of the *geographical region* and the relevant circumstances giving rise to the hominid divergence from the proto-human Primate stem Various localities, usually either in Asia or Africa, have at one time or another been suggested as the site of this significant evolutionary step. I shall in this place briefly outline the evidence which seems to point to-day to that region of Asia north of the Himalayas as the area in question The evidence consists of correlated data derived from three fields of inquiry, namely, zoological, geographical and paleontological The essence of these correlated findings are briefly as follows

The largest land area on the earth's surface, namely Asia, particularly the central area of this vast continent, has long been recognized as bearing a peculiarly significant relation to the geo-

graphical distribution of animal life. This is true with respect to both living and extinct forms. An examination of the distribution of land and water areas of the earth's surface reveals the fact that all the great land masses of the earth are contiguously related to Asia in the northern hemisphere, in spite of occasional separations due to recurrent transgression of the oceans over certain shallow areas, whereas the radiating continental extensions below the equator in the southern hemisphere are separated from one another by wide and deep oceans.

The sequence of events relating to the history and dispersal of the various mammalian forms over these related land areas was set forth most clearly by W. D. Matthew in his historical treatise in 1915 on "Climate and Evolution." The evidence bearing specifically on the problem of the history and distribution of the Primates was later assembled and discussed by Davidson Black in a valuable paper "Asia and the Dispersal of Primates." Both these publications are destined to become classic contributions in their respective fields. They have established beyond reasonable doubt that climatic change must be considered a most significant determining factor in the evolution of land vertebrates and "the principal known cause of their present distribution." The correlated evidence points clearly to the additional fact that "the principal lines of migration in later geological epochs have been radial from Holarctic centers of dispersal"; in many specific instances, it may be added, from the central Asian region of the Holarctic zoogeographical distribution zone. Black was aided greatly in his discussion of the distribution of the various evolving groups of the Primates throughout Cenozoic time by Grabau's paleogeographical maps of Asia covering this period.

The particular findings concerning the relevant events that appear to have been taking place at the critical period of Primate evolution, the period during which the proto-human stock became differentiated from the main Primate stem, may be summarized somewhat as follows: During the uniformly warm and moist Eocene and immediately succeeding periods up to middle tertiary times and before the elevation of the Himalayas, the Asian landscape appears to have presented a relatively simple topography. The climatic conditions over most of this area, at least as far north as the Siberian border of to-day, were such as to favor an extensive forest growth. These facts are attested not only by the fossil records of the plant life in the Oligocene coal beds of Manchuria and other regions of North China but by the distribution of fossil remains of certain browsing animals, among them the giant hornless rhinoceros *Baluchitherium*. Fossil records indicate further that during the early periods of the Cenozoic this extensive area was also the site of a rapidly expanding phase of higher Primate evolution.

In spite of the delayed paleontological exploration of certain portions of the area in question, particularly the Tibetan plateau and adjacent regions difficult of access at the present time, the accumulating fossil records of this critical period in Primate evolution are consistently significant in their direct bearing on the problem of proto-human evolution. The area of greatest concentration of fossil remains of the highly specialized Miocene anthropoids is located in the Sivalik region to the south of the present Himalayas. The faunal and floral conditions making up their natural habitat, as well as that of their immediate descendants, extended at that time uninterruptedly to the north. There is little room for doubt that the remains of these advancing Primate forms will in time likewise be found in the contemporary deposits of the unexplored

contiguous areas in that direction. The fact that *Dryopithecus* has been found as far away as Europe, in the late Miocene strata, is evidence of the fact that these forms were able to migrate widely over their range of suitable environment

Certain generalizations based on the correlation of these biologic and paleogeographic factors become inevitable It is generally conceded, for instance, that the most conspicuous morphological and related changes leading toward human evolution were those occasioned by man's pre-human ancestors leaving the forest and adventuring into the open These morphological changes, made necessary by gradual alterations in the type of habitat, were of the nature of progressive adaptations through the development of potential though dormant faculties. Perhaps the most significant of these dormant faculties, from the immediate functional standpoint, was that of a lower extremity capable of being specialized for unassisted support and progression Such specialization of the lower extremity made possible in turn the subsequent emancipation of the forelimb, and released the evolving potentialities of the human hand Important also among the attributes of greatest potential significance were eyes that had already moved around to the front of the head, thus permitting a more perfect stereoscopic and otherwise discriminating visual examination of nature But of greatest significance of all these proto-human Primate attributes was a brain possessing a cerebral cortex capable of the elaboration of association areas under an increasing influx of new and discriminative sensory stimuli These and other associated morphological and physiological potentialities were among the faculties of the arboreal anthropoids making up the proto-human Primate stem

There is no one better qualified to formulate the paleogeographical and climate changes that brought these evolutionary factors into existence than Professor A. W Grabau, whose critical consideration and first-hand examination of the evidence relating to the points at issue have extended over nearly two decades of intensive paleontological research in China Expressed in his own well-chosen words these formulations are as follows

It is however a pertinent question which can not be lightly put aside what would induce the primitive anthropoids to leave the forest and adventure into the open where the necessity of a radical change of habits would confront them? It is inconceivable that forest dwellers, finding all their needs of food and shelter supplied in their forest homes, could be induced voluntarily to leave it, nor could we assume that they were driven into the open, as long as forests remained anywhere for them to take shelter in. It is only the wholesale destruction of the forests, and the development of barriers which would prevent migration to forested countries elsewhere, that could force these primitive anthropoids to assume a new mode of existence, and compel those capable of adapting themselves to the new conditions to enter the path of development that would ultimately lead to man

The elevation, at the beginning of Miocene time, of the Himalayan Range across Southern Asia would have precisely the effect postulated above as necessary to initiate the new line of development These mountains intercept the moisture bearing winds from the Indian Ocean Infrequent rainfalls and the drying up of lakes and streams, would lead to a depression of the water table, with the accompanying destructive effect upon the vegetation With progressive increase in aridity, the destruction of most if not all the forest trees was brought about

I submit that it is the isolation of the Tibetan region, by the elevation of the Himalayas and other mountain ranges, and the accompanying increasing aridity which produced the environment which alone could lead to the emergence of the human type And I further maintain, that unless it can be shown that Africa or any other region of the world experienced a parallel change in its geographic and climatic conditions at the crucial time, these regions can not lay any claim to being the site of man's emergence comparable to that offered by Tibet and the adjoining districts of Asia

But while the survivors north of the Himalayan Range were forced into this new path of evolution by the radical change in environment, those on the south met with little change in the

conditions of existence Development proceeded entirely along the established lines of simian characteristics, and it can scarcely be doubted that the existing great anthropoids arose from ancestors that remained on the south of the Himalayan barrier or migrated to regions open on the east and west.

Sinanthropus pekinensis, the most primitive hominid of which we have specific or detailed knowledge, therefore requires no forced explanations as regards either his morphological status, his geological horizon or his geographical location. The various factors associated with his discovery are consistent throughout with respect to either or all of these points And the intensive studies of the morphological details of this unique form that are now being carried on by Professor Franz Weidenreich, able successor to the late Davidson Black, are destined to increase greatly our knowledge and appreciation of the significance of the skull, brain and dentitional stages of development found in this exceedingly primitive type of early man

The gap that separates *Sinanthropus* from the nearest known anthropoid forms of lower status is distinctly greater than that separating him from the other fossil hominids of more advanced status. When it ultimately becomes possible to carry out extensive paleontological explorations in late Pliocene and early Pleistocene deposits in regions further west, on the Tibetan plateau and in central Asia, the more immediate ancestors of *Sinanthropus* may be looked for with a very reasonable assurance of their being found There seems little hope at the moment, however, that circumstances will prove favorable in the near future for such explorations In the meantime the fossil remains of various migrants from this area, representing no doubt in certain instances the descendants of intermediate forms between the highly advanced *Dryopithecus* anthropoid forms on the one hand and *Sinanthropus* on the other, will be found in near or far regions of the earth There is some indication that the fossil form *Australopithecus*, found in Africa, may represent such a stage. Considering the vastness of the time involved, there is nothing inconsistent in the discovery of this advanced proto-human form in Africa and the postulated Asiatic origin and area of dispersal as set forth above

On the basis of the relevant paleogeographical and paleontological data now available, therefore, the following tentative chronological outline of probabilities seems to be justified with reference to certain cardinal factors underlying late proto-human and the early human stages of evolution Professor Grabau's summaries of the periods involved will be used, and his term *"Protanthropus"* retained as a designation of the earliest hominids

(1) *Oligocene period.* "Asia mostly a continent of undulating wooded and well-watered lowlands and fertile plains, without high mountains, separated from Europe by marine straits. Primitive anthropoids like *Dryopithecus* inhabited the forests, and *Baluchiterium* roamed the plains."

(2) *Early Miocene* (B C 20,000,000 or earlier): "The Himalayas and other mountains arose in Asia, the Alps, Carpathians and others in Europe Increased rainfall over northern India, aridification of climate over Tibet and much of Central Asia The death, by drought, of the forest trees, forces the surviving anthropoids into the open, while *Baluchitherium* becomes extinct *Dryopithecus* remains largely unaffected and unchanged in the region south of the Himalayas"

(3) *Later Miocene:* "Increasing aridity forces the surviving anthropoids in Tibet, etc, to adapt themselves to the new environment or perish . . *Protanthropus* emerges . . South of the Himalayas, anthropoid development proceeds along Simian lines."

(4) *Early Pliocene:* *"Protanthropus* migrates northward and reaches the well-

watered Tarim basin." While supported as yet by no direct fossil evidence, this hypothetical generalization is nevertheless fully in accord with all relevant subsidiary evidence

(5) *Later Pliocene* (B C 10,000,000–B C 1,000,000) "*Protanthropus* starts his migration east and west, divergent modification characterizing the various branches" The earliest flint industry probably begins during this period and develops unequally in various regions

(6) *Polycene* (a period of transition designated by Grabau between the *Pliocene* and *Pleistocene* in Asia) (B C 1,000,000–B C 500,000), "Descendants of *Protanthropus* reach east China as *Sinanthropus* A branch starting southward reaches Cathaysia where tropical conditions induce retardation in development, and *Pithecanthropus* emerges The westward migrating group splits, one division reaches west Europe as *Eoanthropus* —(possibly with a branch ending in *Palaeanthropus*), another enters Africa and develops features characteristic of *Homo* but retains a primitive culture"

(7) *Pleistocene* (B C 500,000–B C 100,000) "Glaciation of Europe around the borders of the ice sheet Neanderthal man develops his culture Cold dust-laden winds, depositing enormously thick layers of loess, prevented Neanderthal migration to China where *Sinanthropus* may have continued or become extinct . The dismemberment of Cathaysia isolates *Pithecanthropus* who either becomes extinct or under island environment develops an independent Neanderthaloid type"

(8) *Early Holocene* (B C 100,000–?) "The waning of the ice sheets puts an end to the dust-bearing winds, or greatly diminishes them Neolithic man migrates to Europe from the still unknown center of his origin . . .," and also, it may be added, to eastern Asia, where he and his cultures became wide-spread

(9) *Later Holocene:* "Civilization emerges"

In the preceding paragraphs we have attempted to fit together certain fragmentary fossil records and the correlated paleogeographical evidence that are now available relevant to the very earliest stages of human emergence From the seventh (Pleistocene) stage in the foregoing chronological outline onward to the present, the footsteps of primitive man become more and more distinct, although wandering for long periods of time along trails that are still obscure

Despite dire prophecies to the contrary there is no reason to doubt that human evolution still continues forward and upward Generation after generation of mankind persistently come and go Each contributes its mite of human experience to the accumulated progress achieved by the countless generations of the past Continued progress depends as ever on infinitely small increments, derived from individual successes in meeting the physical, mental and social challenges of a changing world The human cerebral cortex strives fitfully and imperfectly to exercise a more reasoned control over reflexes that are strongly conditioned by long periods of animal and savage ancestries Impressed by his increasing mastery over certain of the physical elements in his environment, man feels emboldened to aspire to a self-devised organization and management of human life on this planet Fortunately stronger than the deliberate purposes of reformers or dictators, however, are the human differences they blindly seek to suppress For it is by virtue of these differences—resultants of concomitant variables of race, climate, culture, or biological vitality—that nature, through the continuous processes of elimination and substitution, is able to recruit in each age the vanguard of the forward march

THE ZOOLOGIC DISTRIBUTION OF INTRA-ORAL CANCER

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ALTHOUGH cancer has long been known to occur in practically all species of vertebrates, there has been little scientific interest in animal cancer until recent years From a purely economic standpoint, little or no importance is attached to the frequency of this disease in animals, but the subject is of considerable significance in a study of the cause of cancer in man

For the most part, malignant growths in man and in animals appear to be similar under the microscope and to follow about the same clinical course It would be reasonable, therefore, to assume that they arise from the same cause On this premise numerous investigations have been carried out in series of animals purposefully subjected to specific cancer-producing agents It has long been known that certain forms of cancer—as, for instance, cancer of the skin—can be produced in rats and mice by repeated applications of coal tar Internal cancers can also be produced by the injection of hormones By careful hereditary selection, cancer-susceptible strains of mice have been developed in which the occurrence of the disease in various forms is very high While these studies have served to demonstrate the potency of several now well-known causative factors, they have also further disclosed the complexity of the problem as to the essential nature of this disease

Any discussion of cancer in animals must take into consideration two distinct groups of cases—first, those growths produced experimentally in the laboratory and, second, those arising spontaneously Each group has its special significance, and no informative conclusions can be drawn from pooling statistics of the two The study of experimentally produced cancer has been invaluable in the discovery and investigation of special causative factors For comparative purposes, however, cancer which occurs spontaneously in animals should have a closer relationship to this disease in man and, therefore, should also merit serious consideration

The general anatomic distribution of animal cancer has been discussed in numerous reports, but we have found in the literature no detailed analysis of this disease with regard to the mouth and throat The specific purpose of the present study was to determine as accurately as possible from available evidence the topographic distribution of spontaneous cancer of the mouth in animals as compared to man and, furthermore, to correlate any differences in distribution with known variations in the cancer-producing influences to which man and animals, respectively, are subject We have found in the literature 122 case reports of cancer occurring in the mouths, throats and nasopharynges of animals, and we have also collected 35 cases (not previously reported) by communicating with zoos, veterinary schools and veterinarians throughout the United States and Canada

TOPOGRAPHIC INCIDENCE

In almost half of the cases reported in the literature, the exact anatomic site of the growth is not clearly designated,

cancer is reported vaguely as having occurred in the "mouth," the "pharynx," or the "nose" Such non-specific anatomic classification is, of course, unsatisfactory and probably indicates that the observer was either unfamiliar with the anatomy of these regions or uncertain as to the exact site of origin of the growth In human cancer, that which occurs in the tongue has a different significance from the standpoint of treatment and eventual outcome from that which occurs in other regions as, for instance, the tonsil, and therefore in a study of human cancer great care must be taken in determining the precise origin of a tumor

In Table I are listed the relative percentages of the anatomic forms of intraoral cancer in man and in animals—the latter figures based upon our collected

TABLE I
Anatomic Distribution of Cancer of the Oral Cavity*

	Human beings Per cent	Animals Per cent
Lip	29	15
Tongue	27	18
Buccal mucosa (cheek)	10	5
Jaws	10	39
Palate	9	15
Tonsil	8	5
Floor of mouth	7	5

* These percentages for animals were calculated from our collected cases

series It will be noted that in this group of animals, cancer of the jaws is the most frequent (39 per cent) and, so far as the mouth is concerned, appears to occur in animals with about four times the relative frequency as in man (10 per cent) Tongue cancer (27 per cent in the human being) makes up only 18 per cent of the intraoral tumors in animals However, since it ranks second in frequency in both groups, we see little merit in the emphasis which D'Arcy Power[1] placed on the supposed rarity of cancer of the tongue in animals The relatively high frequency of lingual cancer in man can be rather definitely attributed to such exclusively human causative factors as syphilis and tobacco, and to chronic inflammation of the tongue from other causes from which the animal is practically exempt For instance, leucoplakia (white patches) of the mouth, which may be briefly described as a thickening or callous formation of the lining of the mouth as a result of chronic irritation, and which is found to be a precursor of cancer in man, has never (so far as we know) been reported to occur in animals

It is interesting to speculate as to the reasons for and the causes of the greater relative frequency of cancer of the jaws in animals Dental defects similar to those of middle or old age in the human being are not common in animals and obviously play only a minor role It might be possible that the more natural dietary habits of animals tend to spare the teeth but to produce chronic injuries to the soft tissues around the jaws, while the reverse is true in man The high incidence of tumors of the jaw in animals may also be due, in part, to the frequency of adamantinoma (3 of 12 jaw cases in our series) This tumor arises from the same tissues which develop into the tooth structure in the embryo and not, so far as we know, as the result of any form of chronic irritation It is very rare in man

Cancer of the tonsil and of the floor of the mouth, two fairly common sites of origin in the human being, occur in only slightly lower percentages in animals

Histology

We were able to obtain histologic slides in 20 of our collected cases Dr Fred Stewart, pathologist at the Memorial Hospital, who examined these slides, states that the tumors are in no way distinguishable under the microscope from human cancer He diagnosed as squamous cell carcinoma four cases of tongue tumors, three in dogs and a fourth in a horse Adamantinoma oc-

[1] D'Arcy Power, "Selected Writings, 1877–1930" Clarendon Press, Oxford, 1931

curred in three of twelve cases of cancer of the jaw (2 dogs and 1 horse) Among the other slides in our collected group Stewart found adenocarcinoma (2 cases in the jaws of horses), epidermoid carcinoma (2 cases in the jaws of dogs, one in the jaw of a horse), melanoma (2 cases in the jaws and 1 in the soft palate of dogs), squamous carcinoma (1 in the jaw, 1 in the soft palate, and 1 in the tonsil of dogs), epithelioma (1 case in the roof of the mouth of a dog), and myxosarcoma (1 case in the jaw of a dog)

Age Incidence

In animals, the age incidence of intraoral cancer as well as of other anatomic forms of this disease follows the same general trend as in the human species Malignant tumors of any anatomic variety rarely occur in the young In our collected group of animals with cancer of the mouth, all were adult and many were definitely classed as aged

Some idea of the general age incidence of cancer in animals may be obtained by reference to the report of Cohrs[2] In autopsies on 592 dogs below ten years of age, he found ten cases of carcinoma, eight of sarcoma and one of multiple tumors—a cancer incidence of 3 per cent In autopsies on 145 dogs over ten years of age, he found ten cases of carcinoma, two of sarcoma and twenty-five of multiple tumors—a cancer incidence of 25 per cent Cramer[3] has pointed out that in certain sections there may at times appear to be an epidemic outbreak of cancer in animals, which on closer analysis could be explained by the fact that an exceptionally large proportion of aged beasts had come under observation

Species Incidence

It is evident that the apparent or reported frequency of cancer in animals is influenced by many factors, for example, the relative numbers or the population of the different species and their life expectancy under varying wild and domestic conditions Perhaps more important than either of these is the degree to which any given species is associated with man, since the discovery of cancer in animals requires a certain amount of attention which only domestic or captive animals receive

It is to be expected, therefore, that the majority of reported cases would be found among those kinds which are most numerous or which, for either practical or sentimental reasons, are considered most valuable to man, namely, the dog, the horse, the cat and the cow From the standpoint of a fairly complete postmortem examination, the reported incidence in slaughtered animals would probably be high except for the fact that most of them are killed before they reach the cancer age Trotter[4] reported that although he found 21 cases of cancer in an unstated number of slaughtered aged cows, there were no new growths in 5,300 slaughtered sheep from 6 to 12 months of age

Using the cat and dog as examples, Dobberstein[5] stated that among domestic animals the carnivorous are more susceptible to cancer than the herbivorous However, the high incidence of intraoral cancer in the carnivorous cat and dog may be due mainly to the fact that they are permitted to live to advanced ages while the herbivorous cow and sheep are likely to be slaughtered for food before they reach the age at which cancer usually develops That old age is probably a greater factor than a carnivorous diet is suggested by the fact that the herbivorous horse, which continues to be useful as a beast of burden until old age, is more frequently reported as having cancer than any other animal (Table II).

[2] P Cohrs, *Cancer Review*, 2 197, 1927

[3] W. Cramer, *Cancer Review*, 7 16, 1932

[4] A M Trotter, *Jour Comp Path and Therap*, 24 1, 1911

[5] J Dobberstein, *Berliner tierarztliche Woch*, No 7, p 100

TABLE II
SPECIES INCIDENCE OF CANCER IN ANIMALS

Animal	Upper respiratory and alimentary tract*	Oral cavity alone
Horse	85	33
Dog	43	35
Cat	8	8
Cow	5	3
Trout	3	3
Antelope	2	2
Bear	2	1
Sheep	1	1
Pig	1	1
Hen	1	1
Wolf	1	1
Coati	1	0
Caracal	1	0
Genet	1	0
Raccoon	1	0
Civet cat	1	0
Total	157	89

* Mouth and nasal cavities

In the mouth itself, about an equal percentage of cases occurs in the horse and in the dog The cat seems to be particularly susceptible to cancer of the tongue (6 out of 8 cases, or 75 per cent of the reported cases of intraoral cancer in the cat), in contrast to only about 10 per cent of lingual cancer in dogs and 4 per cent in horses The feline habit (more prominent than in other animals) of preening the fur by licking suggests itself as a possible explanation of this special susceptibility to tongue cancer In answer to our inquiry, Dr C R Schroeder, of the New York Zoological Society, states that there are many wild animals of the feline family who have the same habitual tendency in this regard, but it is to be noted that no tongue cancers have been reported in any feline except the house cat

The true incidence of cancer in wild animals is, of course, impossible to determine, but on rather scanty available evidence the reported frequency as compared to domestic animals is low and lends support to the theory that age plays an important role in the development It is obvious that household pets under normal conditions enjoy unusual longevity By comparison, the lives of wild animals are short. It is a well-known fact that they usually die violent deaths as soon as their physical powers decline, so that they can no longer defend themselves against their natural predatory enemies nor compete with the younger and more robust members of their own species in the struggle for sustenance Even without more definite proof, one would be justified in concluding that in general they do not live long enough to reach the cancer age Moreover, even if cancer did exist, there would rarely be an opportunity to determine and record its presence, whether death is due to natural or to violent causes It is only in zoos that animals of the wild species are observed closely enough for the accurate recording of the occurrence of cancer Even in these animals the incidence is probably increased by the change in environment and the extended life expectancy

It is interesting to speculate whether a seemingly high incidence of intraoral cancer in domestic as compared to wild animals might indicate that new causative factors have been introduced by an artificial or unnatural mode of life Certainly such animals as cats and dogs under domestic conditions do not follow the same dietary habits as their related wild species, nor are they subjected to the same environmental influences in other respects Such a theory has also been advanced by Brooks,[6] who was of the opinion that cancer was extremely rare in wild animals living in their native state and that abnormal living conditions undoubtedly increased the incidence of new growths in the common domestic animals This is interesting as a corollary to the view held by many investigators that cancer in man is a "disease of civilization "

Compared to the change in man's environment from his former primitive to his present civilized condition, the ani-

[6] H Brooks, *Proc Soc Exper Biol and Med.*, 3 39, 1906

mal's transition from the wild to the captive or domestic state can hardly play a major role in the development of cancer. No matter how domesticated an animal becomes, nor how much his new environment differs from that of his wild life, he is still almost entirely free from certain highly significant cancer-producing influences to which man is subject. For instance, from the standpoint of intraoral cancer, the animal is not exposed to any extraneous irritant similar to tobacco or to alcohol. Furthermore, even under the most artificial conditions the animal's food is usually bland and neither hot nor otherwise irritating, since the average beast would instinctively refuse food which did not conform to its natural diet in these particulars. Moreover, the animal is not subject to any disease competent to produce precancerous changes in the tongue, like chronic syphilitic glossitis in man. A disease called daurine, or horse syphilis, is reported to be common in Africa, but so far as we can learn there is no associated chronic inflammation which might be a precursor of tongue cancer.

In certain respects, the incidence of cancer in animals may closely resemble that in primitive races. It has been frequently noted that in primitive peoples both the incidence of and the death rate from cancer is low. Hoffman[7] reports that among the Maoris of New Zealand the death rate from cancer is only 33.7 as against 112.0 per 100,000 in the United States (1937). Lee and others[8] have reported on the rare occurrence of cancer among American Indians. Comparing these peoples to civilized races, this discrepancy might be due not only to a more primitive and therefore more natural environment, but also to a known shorter life expectancy.

Conclusions

The incidence of cancer of the mouth and throat in animals, although impossible of exact determination, is undoubtedly low as compared to that in man. Such a relatively low frequency may be due to a more natural mode of life and indicate that intraoral cancer in man is mainly due to causative factors which have been introduced by civilization and to which animals are not subject. It is only with advancing civilization and increasing intelligence that the environment of any living thing departs very far from the wild or savage state. Considered in this light, no matter how modified the animal's mode of life becomes, it can never be changed to the same extent that modern civilization has altered the environment of primitive man, from the standpoint of cancer development. It is probable that an extension of the normal span of life is the one important contributing factor to an increased incidence of spontaneous cancer in domesticated animals, and that this incidence would be higher if these animals were all permitted to live to an age comparable to the average life of man.

[7] F. L. Hoffman, *Acta Cancrologica*, 1: 279, 1935.

[8] B. J. Lee, *Surg., Gynec. and Obst.*, 50: 196, 1930.

LOOKING FOR AN HONEST MAN

By Professor A A LEWIS
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DIOGENES is back again with his lantern But this time the lantern looks too much like a laboratory to be regarded as a trick of burlesque employed to incite an insurrection against dishonesty The new Diogenes is acting on the assumption that humanity is, finally, in the mood for a G-Man diagnosis and he is, therefore, coming on the scene with a lantern that will actually pierce the surface of outward demeanor, however pharisaical, and show a man up for what he is Deceit is to be revealed, as it were, in terms of candle-power notches

It is not a false assumption that mankind has begun to worry about its behavior and is, accordingly, quite ready for this follow-up appearance of Diogenes We are to-day, from the least sophisticated to the most, very ready to accept the implication that honesty can be so scarce and be so cleverly counterfeited that more than ordinary daylight is required to discover it or penetrate a substitute pretension We have come to believe that a mission in search of an honest man is an important one, as important even as a mission in search of an intelligent one Our intellectual vanity has been forced to concede that there are other personality traits besides intellect which make a difference, and among them is moral caliber

It has been a long time since Diogenes conducted his one-man parade along the streets of Athens in protest against the failure to stress the keystone significance of character in human behavior Taken to heart by contemporaries and successors, the old non-conformist's broad hint should have brought about considerable reformation during the intervening stretch of centuries A geologic period in which to mend its ways, and yet human conduct continues about as badly rent as ever. Little more has been done than to win a theoretical acceptance of the great value of moral integrity noble ideas, apparently, compensating for ignoble living And reference to unconverted human action is not limited to professional offenders, the unscrupulous swindlers who give fine bargains in bogus stocks and the wily criminals, of a thousand specialties, who dupe their victims with unprecedented finesse The ordinary man, the law-abiding citizen thought to be well above board in his public and private actions, is not too good to resort to fraud on occasion He may not be a professional, but in a pinch he can play the game pretty well as an amateur Certainly that man is well above the honesty-average who does not consider it an advantage, frequently, to hide behind a screen of deceit and would not, if he had to step out and reveal the facts, feel like a nudist—a nudist with blemishes Among these offenders against honesty is the common gossip, whose name is legion, the rumor-monger who may go so far as to aid in a whispering campaign to defame, the radio huckster whose blatant exaggeration has only the sky as the limit, the money grabber who signs his famous name to an unqualified indorsement of cigarettes he has never smoked, and last but not least, the political chameleon whose principle changes color with every shift in vote-getting expediency

It is not to be assumed that in all the generations since Diogenes no attempt has been made to solve our moral problems It is true only that the solutions have stopped with kings' charters giving

claim to remote regions; have stopped with vague theory and cloistral speculation. So that the remark, "What personality is everybody knows but nobody will tell," is practically as true of character as it is of personality Through all these long centuries the thing needed to make the theorizing about morals more than mere speculative pastime has been a survey of actual behavior. But it is just recently that students in this field have come to realize—certainly to show by their actions—that nothing short of a measuring scale for morality is going to bring ethical theory out of the clouds and answer such practical questions as How far is it possible to teach morals? Or, What schemes now existing or to be proposed for producing the "cardinal virtues" are to be preferred? And those questions about the effect of the environment, or other concomitant factors, namely What effect, for example, does "company kept" have on one's conduct, or does health or mental level?

Looking for an honest man—a quest which on account of the rarity of spontaneous specimens will, of course, turn out to be mainly a question of figuring how to produce one—has, then, come to be recognized as a venture which needs the cooperative labor of the objective investigator Further, with respect to the steps in the search, it is clear that the first worry will have to be, not the discovery (or production) of an honest man, though that is the end-goal, but the discovery of an improved lantern. Rays must be found which will penetrate deeper into the darkness, whether it is a matter of finding guilt after an offense has been committed or of finding guilt ahead of time in terms of degree of moral liability or, inversely, in terms of amount of capacity to go straight in the face of temptation Finding the offender is apt to be too much like making an inference that the child with a jelly ring around his mouth is guilty of robbing the pantry, though while he was innocently napping the ring may have been transferred there, so to speak, from the face of the actual culprit And only the faker still claims that the lines of the palm, the cut of the countenance, the contour of the cranium and the revelations of the horoscope give a trustworthy tip on future conduct A technique is needed which will locate guilt and establish an index of moral dependability with less beating around the bush by circumstantial evidence and with none of the discredited fortune teller's art What promise is there that our patient and ingenious modern Diogenes, with his deceit-measuring inventiveness, is going to subject guesswork and trickery to much of a purge?

The ambition to apply the yardstick to morals was given its initial boom by the so-called "lie detectors"—the word-association trap which the victim snaps by his own response to verbal bait—and the laboratory instruments for securing telltale breathing curves, blood pressure records and galvanic-reflex readings The operation of the first of these "lie detectors" is illustrated by the city youth who a few years ago arrived in Toronto, Canada, claiming to be a half-civilized bush boy who had been robbed of furs on the northern border, and then pricked the bubble of his clever romancing by replying with "Dempsey" to the word "fighter," suddenly shot at him, and with "first" to the word "safety," and by taking a longer time to reply to incriminating than to neutral words when he tried to hedge The operation of the other detectors—if they had been used in this instance—is easy to picture: the rubber girdle about the boy's chest, the pneumatic sleeve wrapped around his arm, and the electrodes of the galvanometer in contact with his skin—all counting as so many additional triggers to set off the trap

For the most part these "mind reading" devices have been employed for demonstration purposes in the psychological laboratory, where they have been kept (or returned) for further study and

improvement. In the early days when the word response was the only trigger the trap had, few people rated its reliability very high and hardly anybody besides Hugo Munsterberg took stock in the opinion that this new-fangled method of snaring the evil-doer should be substituted for that crude and inhuman method of "working on" suspected criminals, known as the "third degree." But with the multiplication and betterment of these psychological devices and their use in combination, the faith of the few has spread, and it is becoming not unusual to read in newspaper and magazine that the "lie detectors" have been given again—given upon invitation and for practical reasons, let it be added, and not under sufferance to please the whim of some insistent experimenter.

But it is well that popular favor has given its patronage to the "lie detectors" an inch at a time. These detective instruments, like an x-ray machine, may turn culprit or criminal inside out, as by zigzagging curves and dial readings his deeper bodily changes are made visible, but it still remains to interpret the picture. The suspect's guilt or innocence is not spelled out in unmistakable letters. The fact that these deeper, organic reactions are involuntary and can't be made to belie culpability like a face "kept straight," does not guarantee that they can be subject to no other source of causation except actual misconduct. How much more simple the laboratory detective's assignment would be if only, as the Hindus thought, a person moved his big toe every time he lied, and still more assuringly than the Hindu legend mentions, moved it at that time and no other! But the symptomatic correlate of deceit has not turned out to be so easily recognizable or so unambiguous in its significance, and the locating of guilt, even where the offense is large, is requiring all the resource that scientific specialization can command.

It is not claimed, even by the psychological sleuths, themselves, that this new technique makes the detective's art infallible. When asked to give the "lie detector" test to a person suspected of murder, of kidnapping, of embezzlement, of fraternity thieving, of having injured a pedestrian or any of a thousand major or minor offenses, our humane inquisitors feel unhesitatingly certain of their findings only where confession follows. But this dependence on confession for 100 per cent reliability is not to be taken as an admission of zero futility where confession does not follow. Psychological sleuthing is not purely a matter of running a bluff.

The fact that "70 per cent of the offenders confess" when put through the test ordeal would indicate that the guilty individual is routed out of almost his last hiding place. Certainly as compared with the medieval ordeal of having to swallow rice flour, the modern stratagem is an enormous improvement. Though what is sought is still a telltale fear reaction, the dryness of the mouth, as indicated by the state of the chewed rice or the ability of the suspect to swallow the morsel without choking, did not give as trustworthy a clew as does the fear-caused moisture of the skin as indicated by the easily deflected needle of the galvanometer, and this advantage in trustworthiness is more than tripled when circulatory and breathing changes are added. The gain in dependability comes not only from more accurate ways of measuring incriminating responses but also from more artful ways of keeping accused innocence from making such responses, at least from making them with anything but negligible infrequency. If a "dry mouth" is about as apt to convict the guiltless as the guilty, then the same might be expected to be true of a moist skin, for the salivary glands and the sweat glands are about equally beyond the control of the individual under suspicion and about equally sensitive to emotional excitation. There is something to be said for a trap which is so delicately poised that it will be sprung by the cool-

est criminal, but only if it can't be sprung by the excited innocent In order to escape such a fiasco of justice, our modern Sherlock Holmes has attempted, therefore, to keep the guiltless from knowing when excitement will mean guilt and to make enough "inside" references to the crime to allow two or three doubtful responses on the part of the falsely accused to pass as accidental The stimulus words with which the suspect is confronted are selected with a painstaking ambition to make sure that sprinkled among "non-crucial" words there will be "crucial" words, the kind that only the actual perpetrator will consciously connect with the crime or misdemeanor The word "shovel," for example, used as a "crucial" word to catch the slayer of a dog, is no part of a trap to any one except the person who took the animal's life by means of such a weapon, unless publicity has already made such knowledge common property, and this would hardly be true of the majority of the trigger words Only for him does the word "shovel" disturbingly suggest the immediately-tabooed response "dog," and excite questionable skin reflexes (and breathing and blood-pressure changes). That is to say, a trap that is tremulously sensitive to fear is set only for the fellow who knows too much of what went on behind the scenes, and the guarantee that the jaws have clamped on a law-breaker is in direct proportion to the amount of disagreement between the responses to incriminating words and the responses to neutral words

Likely, enough has been said to show that the "lie detecting" strategy is competent to afford some help in the quest for an honest man Old Diogenes would have swapped his lantern for such an improved technique and would have gloated over an opportunity to try it out on some of those popular ringleaders whose deception stirred his cynicism. But if he had wanted to use the "lie detectors" to prevent crookedness rather than to catch the crooks, he would have found their utility limited in two disappointing ways. For one thing, they are not as competent to discover the non-delinquent, or pre-delinquent, child, as they are to discover the delinquent youth, or criminal adult. And for another thing, they have only a snail's competence for accumulating data on a large sampling of individuals Only searchlights which can be turned on a group of individuals, all at once, will supply the abundance of data needed to catch a thief, a liar or a cheater, ahead of time, make it possible, that is, to know to what degree a group (or less certainly, an individual) is potentially dishonest But the "lie detector" method is not alone in the search for an honest man. Two other methods, the biographical and the statistical, have joined in the hunt and are attempting to provide the resources needed to discover the wayward while dishonesty is at a minimum and honesty at a maximum and while it is possible to start the wayward one on the right track without having to back him up so far

The biographical method of looking for an honest man, reckoned from the time it got its name (especially if one designates it by the name, "biometrical"), is a relatively young sort of strategy It has been only a few decades since we began reading about the "juvenile court," the "visiting teacher," "family case-work" and the "child clinic" But in terms of its essential nature, the method dates back to the first attempt to handle a troublesome child by getting better acquainted with him and not by "beating" him

The short-cut of the laboratory magician with his lie-detecting set-up (his polygraph which registers its several findings simultaneously) is at the other pole from the procedure which characterizes the biographical technique The tactic here is that of the clearing house to which a group of banks with overlapping obligations send their accumulated checks for comparison to find out

what the actual disparities are, only in this case the checks are diagnostic items which range from the pick-up of casual observation to the data which is obtained under strictest control In order to discover and clear up any "trouble spots" where character fails to balance, all sorts of diagnostic ingenuities are laid in command, not excepting the "lie detectors" Actuated by the stimulus of a reclamatory goal, which alone can prevent the assembling of facts from becoming a Dead Sea of routine, the field investigator, the psychologist, the physician, the educational expert and the juvenile court judge may all combine to play the rôle of "Good Samaritan" to the neglected youngster who has been beaten by cruel circumstance and left maladjusted by the wayside, and no effort is spared to learn what such a child needs to have done for him so that he may be cured of his injuries, and through follow-up oversight stay cured In gathering information for treatment and guidance, many a stone of personal and familial history is turned, sometimes the investigative ramifications are so varied and exhaustive as to be amazing It is reducing the account of one of these elaborate samples from ninety pages to nine lines to say that practically everybody was interviewed, every written item which might contain a bit of pertinent fact scrutinized, and every resource of science called on for aid What the parents and other relatives—even neighbors—could contribute was tactfully elicited, school records, including teachers' opinions, and health records, both mental and physical, and for parents and grandparents and other near relatives as well as for the child, himself, were conscientiously sought, and numerous blanks were filled with the data obtained by physical, psychological and psychiatrical examinations And, of course, a clinical inventory could not be considered exhaustive unless it included the youngster's autobiography, the inside facts, usually gained through friendly and informal conversation, but sometimes supplemented by the more formal maneuvering of the psychoanalyst

Imagine some distinguished personage submitting to a biographical overhauling so revealing and authentic! Only a Rousseau or a De Quincey—two in a million—would permit so much truth to be brought to light Needless to say, such an unrestricted inventory is rare even in a clinical biography, though this is not because the loss of reputation is greatly at stake A clinical diagnosis, in contrast to a "debunking" biography, is kept as private as possible and not advertised to the four winds The expense is the rub, it is too great for charity to carry, and the general public is not yet willing to bear the burden through social security taxation Yet, however infrequent this elaborate case study, it serves to show how far biographical lantern-bearing is competent to throw light on the classification of children according to character, and to acquire, thereby, the wisdom necessary to guide in the rebuilding of weak places

It is unquestionably true that, by acting on the proposition which holds the restoration of the offender to be more important than the figuring out of a penalty commensurate with the offense, the biographical method has been able, through reducing dishonesty, to supplement the purely negative "lie detecting" method of looking for an honest man But still there is room, after the laboratory detectives and the clinical biographers have done their utmost, for some Diogenes to be skeptical about our being able either to find or produce an honest man The detective machinery can, at best, do little more than make the gross distinction—guilty or not guilty, and the biographical cross-checking procedure can do little more than make gross qualitative contradistinctions, than classify a particular problem youngster as a first-time offender or a repeater, or as a normal delinquent or a constitutionally psychopathic one Furthermore, each artifice—especially the first—is open to

the criticism of having arrived after the thieving (lying or cheating), in such amounts as to shock society, has already occurred; and it follows, of course, that each artifice has the limitation of not being able to check with any nicety on how much progress is being made—or can be made—through any reclamatory program

But it would seem that in this matter of finding an honest man, invention is not going to stop short of a thoroughgoing attempt at discovery; for a third method, the statistical, has joined in the search and is undertaking, specifically, to remove those last doubts of skepticism This method, which aims to get data on more and more individuals (mainly school children) and keep it up until the data are inclusive enough to make possible the discovery of authentic measuring devices, is, just now, in the thick of a struggle against the necessity of treating honesty merely as a qualitative fact (as hedonistic ethics through long centuries has had to treat happiness and pain and continually fail to obtain their algebraic sum) It would reduce trustworthiness (or untrustworthiness) to quantitative units, and do it with a measuring scale whose subdivisions are sufficiently small to give a reading on delinquency while still in the pre-delinquency stage, to furnish a criterion for reckoning with some exactness, and ahead of time, the amount of moral vulnerability (or resistance to temptation), and to appraise with practical dependability both the relative merit of different character-education schemes and the comparative potency of such concomitant factors as intelligence, physical vitality, cultural background, school achievement, company kept, home conditions, and so forth

To provide for the measuring of capricious character a scale of such instrumental dependability and wide serviceableness is an accomplishment which only the future can guarantee The fractional results secured in the parallel task of measuring intelligence, though sufficient to embolden with some confidence, have not failed to teach prophecy to be modest when it comes to the question of measuring something which is not only difficult to define, but difficult to isolate—to tease out of the behavior tangle—however ingenious the technique employed. Our investigators of character are confronted with the same question which has confronted the students of intelligence, namely. "How translate a vague intangible into objectively computable conduct, and by so doing bring it under predictive control?" Which in this case means, "How prevent dynamic nature from running wild in delinquency and crime?" And the answer, again, is. "Do it by running the individual through a gauntlet of standardized situations, called tests, and then calculating the score by means of statistical devices."

The requirement laid upon any measuring instrument that it have a base line from which to make its quantitative calculations and that it have its subdividing notches identical throughout the instrument's range, are hard exactions for any "mental testing" scheme to satisfy, and character testing in its own way must pass through these fires

Locating a zero point for deception is analogous to doing the same thing for handwriting, and in the instance of one scale of penmanship specimens, the specimen which is just illegible takes the base line position A rather fuzzy line, but better than none, and this double declaration holds for the base lines so far figured out for the various tests being used, cooperatively, to grade character; they too are in the rough, but they are a move in the direction of a precision that is better than saying, for example, that the zero for morals is the dividing line between being in and being out of the penitentiary It is safe to consider it an improvement upon the old dichotomous classification which says that an

adult or a child can either be trusted 100 per cent., or can't be trusted at all, and consigns all deception, of whatever degree, to the same diagnostic black hole

Least elaborated are the statistical attempts to make a quantitative diagnosis of stealing and lying In the matter of theft, "coins" have been substituted for the "pepper-filled cherries" of the old McGuffey Reader The merchant, there told about, would have come nearer to finding an honest boy to serve as clerk, if he had placed money instead of cherries on the table in the waiting room Money has the advantage of providing about the same degree of temptation to every prospective sucker One youngster may crave some particular article more than another, indeed may not have the least craving for cherries, but a nickel is no particular article, it is five cents worth of whatever is most dear to the heart

In the matter of lying, the dishonest are caught by an assortment of questions which relate to behavior standards and tempt the interrogated to angelic pretensions "Do you always keep every secret that you promise to keep?" is one question. "Did you ever write your name in the books you use which belong to the school or library?" "Do you always congratulate your opponents?" "Did you ever hurt or cause pain to a dog, cat or other animal?" "Did you ever blame another for something you had done when you knew all the time it was your fault?" "Did you ever take anything (even a pin or a button) that belonged to some one else?" These are other questions; and there are still others, enough altogether to make any one but a "pious fraud" acknowledge some shortcoming

In the check-up on thieving or falsifying, the character-testing technique is close to the starting point in its development into a measuring scale In the contempting set-up the tempted individual either steals one, or more, of the coins, which he has an apparently safe opportunity to steal, or he does not Having provided a lure and a promise of escape that closely duplicate life's own realism, the tester needs only to look at the scale-beam, as it were, and take the readings, in order to know whether the tempted one is guilty or not, and in order to have a basis for predicting future conduct—a past on which to base an index of (some) trustworthiness Also, in its relatively undeveloped strategy, cornering a falsifier does not involve a great amount of statistical juggling

It will, therefore, be advantageous to shift our story before going deeper into the statistical technique, since it is in connection with cheating that the attempt to find a borderline between honesty and dishonesty, and a dependable scale unit to measure distance from this line, has carried the maneuvering to greatest lengths

To find a zero point from which cheating can be calculated it has been necessary to find the average score of a group of individuals in a standardized performance and, then, to correct the middle score by making an allowance for legitimate fluctuations. The size of the correction is the average of the "gains and losses" of the same participants in a second undertaking which, in difficulty, is a twin of the first This procedure has the sanction of everyday observation A group of golfers, for example, playing a standardized course to-day and a different, but equally difficult, course tomorrow, would hardly be accused of cheating if the average for the second set of scores differed somewhat from the average for the first set Cheating can be counted only from the point where chance fluctuation ends

If when unsupervised, an individual's score rises above the level of legitimate upward fluctuation from the corrected middle score, by so much is it made probable that the score is too good to be true. And if this rise in fluctuation is as much as three sigmas above the honest-average

fluctuation of a large enough random selection of individuals to give a surface scatter of scores comparable to the side-view of an admiral's hat, the probability that cheating has occurred is about 999 in 1,000 This estimate is based on the fact that in a normal distribution of scores a scatter of six sigmas—three on either side of the central score—wipes up 99 73 per cent of the cases and reduces the chance of occurrence for a deviate of 3 sigmas to 1 17 in 1,000 From these figures it would appear that one would have to be a terrible sinner to be caught, but this is true only where the calculation is based on a one-test temptation With a considerable number of tests all pointing a finger at an offender much smaller single probabilities will convict It would take a whale of a drop in a golf score to give "hanging certainty" of dishonesty, but were there probability of cheating in business, in lodge affairs, etc , as well as in golf, much smaller amounts of probability would give highly reliable grounds for the assessment of guilt

We are not forgetting, of course, that dishonesty is not satisfactorily measured until its probability is calculated with respect, not only to the past, but also to the future It is important to know the degree of probability that an individual has committed an offense, but it is equally important to know what are the probabilities that he will repeat if he gets a chance, if he faces a similar temptation

The amount of certainty with respect to the eventualities connected with any particular individual is less, as is generally known, than the amount of certainty with respect to the group. A life insurance company can base its financial security on a group life-continuance probability which guarantees nothing about the longevity of any single member of the group Very little trespassing by our golfers as a group, beyond the limit permitted by honest fluctuation, would suffice to guarantee not only that cheating had been committed but that—without the intervention of some Billy Sunday—it would occur again under similar circumstances and in about the same amount.

Character tests, competent to check on the group as a whole, will make it possible to calculate the comparative effectiveness of Scout participation and Sunday-school attendance, of instruction which points a moral and instruction which lets noble conduct speak for itself, to calculate the anti- and pro-moral influences of slum and select communities, of broken and intact homes, of bad and good companions, and to calculate—as intelligence testing now does in its field—how well certain types of future stresses are going to be withstood, to know ahead of time the morality risk But if the statistical maneuvering is going to be competent to measure with any such trustworthiness the effects of training and circumstance on the conduct of a particular member of the group, the tests used will have to be greatly refined and multiplied. an accomplishment which will require a "vast amount of work" and an abundance of inventive genius

In endeavoring to measure honesty in school children (the investigator's most accessible subjects) the procedure duplicates to a striking degree the earlier attempts to get a line on such a simple ability as spelling, and in the later endeavor the object is, again, to know when and how much—if any—progress is being made in school and to grade the methods and devices in vogue, or proposed, for educative promise It is in the scaling of ability to be honest, just as it has been in the scaling of ability to spell, a question of finding hurdles that in smallest number will provide a basis for rating a question of collecting a list of more and less difficult words from among those most frequently used, in the one case, and of "collecting a list of situations in which deceptive behavior is more (and less) frequently practiced," in the other. The tempting situations are realis-

tic samplings from school, home, playground and party. such temptations as are provided by an opportunity to go against instructions and get help on home work, to use a key not only for grading a standardized arithmetic test but for slipping in a few corrections, to add to a performance in a speed test by writing answers after time has been called, to reach the floor and give weak arms a little help in chinning the bar, and to peep when making the turns in a pencil maze or when pinning the tail on the donkey

There are around thirty such baiting situations, already contrived, and in connection with each situation some one of a half-dozen different traps is set, traps, called "techniques," and of such camouflaging merit, when ideally constructed, that they can be used again and again with the same children The deceiver walks into the trap, is caught and is checked on for guilt without waking to the fact that his morals have been scientifically scrutinized The child who thinks he has improved his showing when he uses a key to doctor his performance on an achievement test is living in a fool's paradise, because the "duplicating technique," by paraffine impression or some similar method, has provided a double of the bona-fide answers And in like manner the "overstatement technique" works behind the scenes to trap the young pretender who sanctions inflated estimates of his accomplishments by answering "Yes" to such questions as "Did you receive 95 on your last examination?" "Did you chin the bar 20 times without stopping?" "Did you do your homework without aid from any one?" Then there is the "improbable achievement technique"—to mention a third pitfall It snares the unsuspecting by setting tasks that, under the rules to be followed in their execution, are well beyond normal human capacity. It is this trap which catches the fakers who with eyes closed thread mazes of such difficulty as to belie the visual handicap, or in the five minutes allowed, perform the improbable feat of clearing a "peg solitaire board," checker-jumping fashion, of all but one of its thirty-three pegs

At present these baiting situations are too few and the trap-setting too amateurish to provide a very reliable scale for grading honesty But through the statistical study of character, science is going to provide our modern Diogenes with a third lantern of very piercing rays And then equipped, not with one but three lanterns, his quest along the streets of to-day should not be doomed to complete disappointment Not that he should expect to find a perfectly honest man—for sanctified citizens exist only in ideal realms, but such honesty as there is he might expect to find, mixed in each individual instance with more or less dishonesty Through the instrumentality of the lie-detector lantern, he should be able to find those in whom the alloy of dishonesty exists in rather gross amounts, through the instrumentality of the biographical lantern, whose rays are partly of the ultra-violet sort, he should be able to bring the youthful delinquent into view before he has fallen into the clutches of the belated policeman or the plain-clothes detective, and through the instrumentality of the statistical lantern, whose brightness reveals dishonesty in smaller and smaller subdivisions, he should be increasingly able to guide education in the more ideal task of preventing dishonesty

In very wishful spirit, we hope that the multiplying successors of Diogenes will keep looking for that "honest man" and that their looking will lead to the discovery of a way to teach morals just as surely as arithmetic is taught, a way to stock this pestilential world so full of honest men that one can be found for every office

BOOKS ON SCIENCE FOR LAYMEN

A WAY TO UTOPIA[1]

THIS almost encyclopedic volume by one of Great Britain's able young scientists is on a subject of wide interest throughout both the democracies and the totalitarian countries to-day. Perhaps no one is better qualified than Bernal to write such a book, for he has a wide knowledge of science, the vigor and daring—and also the hopefulness—of youth, a zealous interest in the subject and a clear and vigorous style Yet in reading his censure and his praise we should remember that his youth was darkened by the tragedies that fell on nearly every British family during the World War, his early manhood was disturbed by the severe readjustments that were necessary in the following decade, and during the past ten years he has seen almost world-wide economic dislocations and now the menace of a new war We are affected by our environment, sometimes profoundly

The book consists of two parts, "What Science Does" and "What Science Could Do." Of these two parts, the former is the more interesting and probably the more important, although the latter contains many penetrating suggestions, as well as some that enter on the fantastic —such, for example, as diverting ocean currents and developing interplanetary navigation to escape final destruction of the human race

In the introductory chapter we find, "The new methods of production which science has brought into being lead to unemployment and glut without serving to relieve the poverty and want which are as widespread in the world as ever before At the same time, the weapons devised by the application of science have made warfare a far more immediate and more terrible risk, and have diminished almost to vanishing point that personal security which was one of the chief triumphs of civilization. . . . War, financial chaos, voluntary destruction of goods which millions need, general undernourishment, and the fear of still other wars more terrible than any before in history, are the pictures which must be drawn to-day of the fruits of science " Even in the disturbed days of the past decade such words could be written only by one whose experience did not extend far back and who ignored the starvations, the pestilences, the wars, the cruelties that have blackened nearly every page of history This tendency of the author to use in his comparisons some undefined ideal instead of historical realities is characteristic of the crusading spirit Yet many of his barbed shafts have reached legitimate targets With excellent aim he shoots his arrows at the weaknesses of the teaching of science in both secondary schools and colleges, at the defects of its uses in industry and government, at the lack of coordination of science, at industrial competition, at monopoly and at many other things which are short of perfection These criticisms are not simply striking comments about imperfections, but are thoughtful opinions, often supported by evidence, on questions deserving careful attention

In the chapter on "International Science," which contains a brief survey of science throughout the world, the attitude of the totalitarian countries toward science is very severely, and on the whole justly, dealt with Indeed, Fascism and the Nazi form of it are unsparingly condemned both as basic theories and in practice He quotes Herr Dr Stark's remarkable article in *Nature* and in "Das schwarze Korps," and numerous excerpts from Chancellor Hitler's "Mein Kampf." There is no kind word for Germany or the Germans of to-day, al-

[1] *The Social Function of Science.* By J D. Bernal. Illustrated. xvi + 482 pp. $3.50. Macmillan Company

though the Germans are actually a great people who undoubtedly in the not distant future will again join with all other peoples in promoting the science and civilization of the world

After reading Bernal's strictures on Fascist Italy and Nazi Germany, one is not prepared for his unvarying enthusiasm for the Soviet Union Over and over again he speaks of the Soviets with warm approval and without a word of criticism. He exalts the words of Marx, Engels and Lenin respecting the organization and use of science On page 222 we read. "For the last twenty years the prevailing social system has not been universal There has existed in the world a country in which the basic method of production and social relations have been quite different and consequently the relations of science to society have been so too The Soviet Union differs from all previous civilizations in having been to a large extent thought out beforehand and in being man's first conscious effort to mould the very framework of his own activities The basis of these conceptions lay in the criticisms of developing capitalism which was carried out over the last hundred years by Marx, Engels, and Lenin " These strong words about the Soviet program having been thought out beforehand are partly contradicted by (p. 226) · "The organization of Soviet Science is somewhat complex and is by no means yet fixed. In the early stages many inprovisations were made, some of which have been retained and others dropped " But this is about the only admission that the feet of the Soviets are partly of clay.

The uncompromising partisanship of the book, emphasized over and over again in many paragraphs, gives the reader an uneasiness that he would not otherwise have The Russians are undoubtedly a great people who are destined to contribute much to the progress of the world. But they have not yet reached Utopia, even in science, as Professor Edwin G. Conklin learned when he found that his book, "Heredity and Environment," translated with his permission by a Russian into Russian, in 1935, had certain paragraphs and even entire chapters omitted, without notice to the reader that they had been omitted, because they did not agree with Soviet ideology Such an occurrence takes much of the weight from Bernal's boast of the number of scientific books that have been translated into Russian More recently there have been several occurrences that indicate that the science of heredity, as it has developed under the influence of the Mendelian law, is not in favor with the rulers of Russia The International Congress on Genetics, which was to have been held in Moscow last summer, was suddenly cancelled by the Soviet authorities Still more recently the work of Professor Vavilov, one of the best students of heredity in Europe, has been condemned and, according to reports, "Mendelism and Morganism have been denounced because they do not accord with the principles of our Government "

Probably quite unconsciously, the author falls into an attitude common to the people of all totalitarian states and which appears to be becoming acceptable in this country That attitude is that an end which appears to be desirable to those in power justifies force to secure it This idea lies back of all emphasis of the supreme importance in science of organization, cooperation, avoidance of waste, production purely for social purposes and not for profit and similar high ideals set forth in many pages As I said, I think it was not realized by the author that these ends can be attained in the near future only by a political organization willing to employ force In fact, he speaks often of the desirability of freedom in science But uniformity in science and other intellectual pursuits would be more difficult to attain than uniformity in matters pertaining to the body. As desirable as it might be from some points of view, I doubt that the

author would seriously advocate in the interests of efficiency and economy the adoption of a uniform diet designed only to provide the necessary nourishment or that clothing or dwellings should be standardized for similar reasons It would be easier to secure conformity in these things than in some of those he advocates The history of life on the earth, and of the advancement of civilization as well, proves the fact that progress is gradually achieved by enormous diversity with many failures, as well as a few successes, and that uniformities lead to stagnation and often to extinction There is no evidence that man has yet developed mentally to the point at which he can safely avoid diversity and abandon the methods of almost reckless experimentation I am confident the the author would agree with these sentiments, though many of the things he advocates seem to imply the opposite

F R M

FOOD FROM THE WILD[1]

For over thirty years Professor Medsger, a gifted naturalist and inspiring teacher of nature study, has been collecting data on the wild plants of North America which yield food for man; and now that he has retired from active teaching, he has fortunately been able to publish the results of his studies in the excellent book before us The work is divided into sections dealing successively with fruits, nuts, seeds and seedpods, salads, roots and tubers, beverage and flavoring plants, sugars and gums and mushrooms Under each, the species are arranged in the order followed in standard works on botany, the international system of nomenclature being followed Under the individual species there are given full descriptions of the plant, data as to its geographic range and notes on the edible parts and how to use them, based in numerous instances on the author's own wide experiences The text is liberally interspersed with bits of poetry, quotations from early writers on the foods of the Indians and similar material At the end there are given useful tabulations of the species included, arranged in four geographic categories—northeastern, southern, midland and western Finally, there is a general index nearly nineteen pages in length

Many of the food plants included are of course familiar to every one who hikes in the woods, but some of them are rarely if ever recognized as edible. Skunk cabbage, when boiled thoroughly, with two or three changes of water, and then seasoned, is recommended as having a pleasing taste Common milkweed, when well cooked, is described as much like spinach Chickweed, "when properly prepared, makes a splendid potherb I have tasted its edible qualities, and can recommend the plant"

That there are elements of danger in eating some wild plants is clearly recognized The author points out that it is not desirable to eat many Canada yew berries at one time, and the seeds should not be chewed nor swallowed He gives a graphic description of the severe colic he suffered when, as a lad of eight, he ate all the May-apples he could Labrador-tea he finds to make an agreeable beverage, but advises against drinking more than a cup at a time because of its narcotic effects

Every one who camps out in the woods and who knows enough about botany to identify the commoner plants will certainly wish to make use of this book to aid him in supplementing a monotonous diet of canned goods with native novelties

Edgar T Wherry

[1] *Edible Wild Plants* By O. P Medsger. Illustrated xv + 323 pp $3 50. Macmillan Company

WHAT IS DOWN BELOW[1]

This volume, one of the series on various physical properties of the earth pub-

[1] *Internal Constitution of the Earth.* Edited by Beno Gutenberg Illustrated ix + 413 pp $5 00 McGraw Hill Book Company.

lished under the auspices of the National Research Council, is not a light book for casual reading during a vacation. On the contrary, it undertakes to set forth for specialists, and with no attempt at avoiding technical terms, what has been learned about the constitution of the interior of the earth The subject is very complex and presents serious difficulties and uncertainties in conclusions, as is indicated in the preface "There remain only those irreducible disagreements which are inevitable with reference to a subject that combines the results of so many divergent and highly active fields of investigation"

After an introductive chapter by the editor, Harold Jeffreys, of Cambridge, England, discusses the origin of the solar system, forgetting, however, the twenty years he held to the Laplacian theory after it had been abandoned in this country, and an equal interval in which he clung to the fission theory of Sir George Darwin of the origin of the moon from the earth Nevertheless, he has written an excellent summary of the subject assigned to him

Reginald A Daly, of Harvard University, follows with a chapter on the inferences that may be drawn from geology Then L H Adams, director of the Geophysical Laboratory of the Carnegie Institution of Washington, contributes a chapter on the elastic properties of the materials of the earth's crust The closely related subject of the relation of the earth's crust to its interior is treated by H S Washington, also of the Geophysical Laboratory C E Van Orstrand, of the U S Geological Survey, discusses the observed temperatures in the earth's crust, followed by a chapter on the cooling of the earth and the temperature of the interior of the earth, by B Gutenberg, and two additional chapters by the same author on the forces in the earth's crust and on hypothesis respecting the development of the earth's crust

J B. Macelwane, of St Louis University, contributes a chapter on conclusions respecting the interior of the earth from earthquake waves, after which he continues with conclusions from deep-focus earthquakes The remaining chapters are by the same author, with the exception of one on the density, gravity, pressure and ellipticity in the interior of the earth, by Walter D Lambert, of the U. S Coast and Geodetic Survey

F R M

ACCENT ON ODDITY[1]

THREE centuries ago, reputable authors described fishes with monks' heads, unicorns and tritons that played tricks on fishermen Those fictitious monsters have lost scientific standing, only to be replaced by an array of actual animals which seem almost as grotesque and surprising

To these living "unbelievables" of the zoologic world, Mr Verrill has dedicated a series of books In these, the fifth and sixth volumes, he tells us about fishes that walk, beasts that lay eggs and a great variety of other creatures which violate, in one way or another, our ideas of what animals are and do

They violate *our ideas;* that is significant Though Mr Verrill labels them strange, or misfits, most of these animals belong to ancient lineages which were established on earth ages before man began to decide what was queer and what was commonplace It is we who marvel, not they that are essentially marvelous, our amazement at their forms and ways is a measure of our unfamiliarity with the biologic world In so far as Mr Verrill's books reduce that unfamiliarity and contribute to understanding, they perform a good service If they merely intensify our willingness to marvel, they are likely to do harm

C L F

[1] *Strange Fish and Their Stories* By A. Hyatt Verrill Illustrated xix+220 pp *Strange Animals and Their Stories* By A Hyatt Verrill Illustrated 235 pp $2 50 each L C Page Company.

PHYSICISTS WHO TOOK PART IN THE COSMIC RAY SYMPOSIUM

(1) H. A. Bethe, Cornell. (2) R. R. Brode, California. (3) A H. Compton, Chicago (4) E Teller, George Washington (5) A Baños, Jr, Mexico (6) M S. Vallarta, M I T (7) S A Goudsmit, Michigan (8) J. R. Oppenheimer, California. (9) C D Anderson, Calif I. Tech (10) V. F Hess, Fordham (11) B. Rossi, Manchester (12) W. Bothe, Kaiser Wilhelm Institute (13) P Auger, Paris (14) W Heisenberg, Leipzig (15) T H. Johnson, Bartol (16) J Clay, Amsterdam (17) F. Ehrenhaft, Vienna (18) W F. G Swann, Bartol (19) S H Neddermeyer, Calif. I Tech. (20) G Herzog, Zurich-Chicago (21) W D. Harkins, Chicago (22) H G Beutler, Chicago. (23) D K Froman, McGill (24) M. Schein, Chicago. (25) C G Montgomery, Bartol. (26) G Grotzinger, Vienna-Chicago (27) L. W Nordheim, Duke. (28) E O Wollan, Chicago (29) S E. Forbush, Carnegie I. Washington (30) W M Nelson, Duke (31) V C. Wilson, Chicago (32) H Jones, Chicago. (33) O Godart, M I T (34) A. Haas, Notre Dame (35) M. A Pomerantz, Bartol (36) R. S Shankland, Case (37) C Eckart, Chicago (38) J. C. Stearns, Denver (39) J J. Hopfield, Toledo (40) W P. Jesse, Chicago (41) B J Hoag, Chicago (42) N. Hilberry, New York U. (43) F R. Shonka, de Paul (44) P S Gill, Chicago. (45) A. H Snell, Chicago (46) E J Schremp, Washington (St. Louis) (47) E Dorshem, Chicago (48) C Holley, Chicago (49) R. B Sawyer, Centre College (50) F L. Code, Vancouver.

THE PROGRESS OF SCIENCE

CHICAGO COSMIC RAY SYMPOSIUM

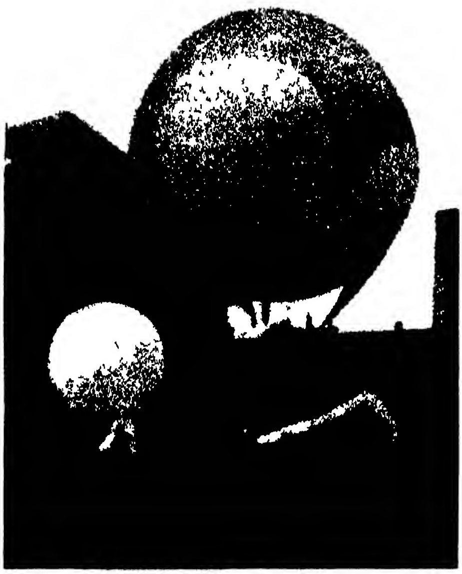
DURING the last week of June there was held at the University of Chicago a notable symposium on cosmic rays A large proportion of the active students of cosmic rays throughout the world were in attendance These included Victor Hess, now of Fordham University, whose balloon experiments in Austria in 1912 established the existence of the rays, Carl D Anderson, of the California Institute of Technology, who discovered positive electrons among his cosmic rays and found evidence for the presence also of the new sub-atomic particle, the meson, Werner Heisenberg, of Leipzig, of quantum theory fame, who has done much in interpreting the action of cosmic rays, W Bothe, from Heidelberg, and Bruno Rossi, from Padua, whose counter tube experiments have demonstrated the corpuscular properties of the rays, and leading representatives of other research groups from England, Holland, Canada, Mexico and the United States

In modern research in the fundamentals of physics, the study of cosmic rays has occupied less attention than that of the structure of the nucleus of the atom or of the interpretation of spectral lines Its students, however, believe that in cosmic rays we have the most effective tool for studying the components of atoms and how their nuclei are put together Just as when the study of x-ray spectra helped us to solve the problems of the electronic atmosphere of atoms, so, it is hoped, the study of cosmic ray processes will clarify our understanding of radio-activity and other nuclear processes, and lead to the next great advance beyond the quantum theory It was perhaps this feeling of the great intrinsic importance of their investigations which accounted for the concentrated interest and attention on the part of the galaxy of notable physicists during their four-day session

Among the major findings reported may be mentioned conclusive evidence for the existence of mesons, new data with regard to their remarkable penetration, evidence that they can be formed as rays in the atmosphere by the impact between energetic particles, and apparently also of their spontaneous disintegration by a kind of radioactive process Neutrons are much more abundant in cosmic rays than had previously been suspected, though the less massive neutrettos and neutrinos remain on the list of mere suspects It now seems probable that the incoming cosmic rays consist of protons, and that these come from our own galaxy, with energies of from a billion to a million billion electron volts

It is noteworthy that the subject of how the cosmic rays are produced, which was the center of attention a few years ago, occupied no more than five minutes of the twenty-five hours of busy sessions of the symposium Their origin remains a mystery Of more immediate concern has been the problems of finding the composition of the rays as we observe them on the earth and of learning what the rays do as they pass through matter

First to be identified among the cosmic rays in our atmosphere were electrons and photons Pierre Auger of Paris reported the remarkable observation that these particles frequently occur in widely spread showers, sometimes as far as a thousand feet apart, all appearing to originate from the same parent ray high in the atmosphere The energy of the original ray which gives rise to such a shower of photons and electrons must sometimes be greater than a million billion electron volts, far greater than any other known type of ray Dr Serge



PROFESSOR PIERRE AUGER
OF THE UNIVERSITY OF PARIS, ASSISTING IN A COSMIC RAY BALLOON FLIGHT FROM STAGG FIELD, UNIVERSITY OF CHICAGO, ON THE FIRST DAY OF THE SYMPOSIUM

Korff, of the Bartol Research Foundation, described a series of his high altitude balloon flights in which, associated with these photons and electrons, he found the existence of a large number of neutrons For detecting the neutron rays he used the novel technique of filling his counting tubes with a gas containing boron, which has the remarkable property of absorbing neutrons and becoming radioactive The detection of the neutrons is then made possible by observing the disintegration of the boron atoms Korff observed that the rate of increase of neutrons is even more rapid with altitude than is the increase in the main body of cosmic rays It appears possible that the neutrons result from the disintegration of the nuclei of nitrogen atoms when struck by the primary cosmic rays that come in from outside the atmosphere

Carl Anderson and Seth Neddermeyer, of the California Institute of Technology, reviewed their now classic experiments, which show in a cloud chamber between the poles of a powerful electromagnet the distinctive paths followed by the various types of cosmic ray particles Positive and negative electrons were made evident and new and more conclusive evidence was presented for the existence of mesons Robert Brode, of the University of California, added the results of somewhat similar studies in which he was able to count one by one the ions along the paths of these various particles W Bothe, of the Kaiser Wilhelm Institute at Heidelberg, added strong evidence of a similar type If there had been any doubt of the reality of the meson, none of the investigators present felt that the evidence could now be questioned

Volney Wilson, of the University of Chicago, reported measurements of cosmic rays made in various underground locations, down as far as 1,600 feet below the ground, which revealed the existence of the penetrating meson at least to a depth of 400 feet On the basis of his own new experiments at great depths, J Clay, of Amsterdam, suggested that below 400 feet the predominate form of radiation may be of a different type, namely, neutrinos, whose existence has for several years been suspected Whether this view is correct remains to be answered by further experiments

It has been more difficult to learn the composition of the rays which come into our atmosphere from outside beyond the reach of our laboratory instruments Because of the manner in which the earth's magnetic field bends the paths of these incoming rays, it has been known for some time that they are electrically charged and that this charge is

predominately positive The physicists from Bartol Research Foundation—W F G Swann, T H Johnson and Mr and Mrs C D Montgomery—brought forward cogent experimental and theoretical arguments favoring the view that these incoming rays are protons, the positive nuclei of hydrogen atoms Heretofore most physicists have doubted the adequacy of protons as an explanation for cosmic ray effects because it was supposed that particles as heavy as these could not produce the photons and electrons that are found so abundantly among the cosmic rays at high altitudes A discussion of the mechanism of the production of mesons, however, by Werner Heisenberg, of Leipzig, indicated that very probably protons should be more important in affecting atomic nuclei than should any of the lighter types of particles On this view not only the meson but photons, electrons and neutrons, as well, would all be emitted when a proton coming to the atmosphere from the outside would make a close collision with an atomic nucleus

Where the rays originate is a question whose answer is being sought by a group of investigators whose work was reported by A H Compton This study concerned itself with an investigation of the relative intensity of the cosmic rays in the northern and southern hemispheres, a series of measurements being made on board a ship plying between Canada and Australia and Tasmania. If the rays came from beyond the Milky Way, because of the motion of the earth with the rotation of the Milky Way, more of these rays should be received on the front than on the back of the earth The

BERNARD A. ECKHART HALL FOR PHYSICS, MATHEMATICS AND ASTRONOMY
WHERE THE COSMIC RAY SYMPOSIUM WAS HELD, AND WHICH, WITH RYERSON LABORATORY (LEFT FOREGROUND), HOUSES MOST OF THE PHYSICS RESEARCH OF THE UNIVERSITY

front in this case is the northern hemisphere The result of three years' observation was to indicate no difference between the rays received in the two hemispheres within a probable error of about one part in a thousand Since an effect of about one part in two hundred was anticipated due to the earth's motion, this seems to mean that the rays share the rotation of the Milky Way and, hence, are presumably a part of our own galactic system. Though this result supports the conclusion drawn last year from a study of the daily changes of cosmic rays, the result is still somewhat uncertain, pending further theoretical and experimental investigations Tentatively at least, however, the "cosmic" rays that we receive seem to be of no more remote origin than are the stars that belong to our galaxy

One wishes there were time to consider, as M. S Vallarta and Victor Hess have done, the way in which the cosmic rays are affected by the magnetic field of the earth and apparently likewise of the sun In these effects lies an important method of determining the energy of the rays as they approach the earth, which varies from about a billion to a million billion electron volts

As was to be expected at a stage of investigation where the experiments are not yet highly refined, there were some disagreements as to the exact nature of the data Most prominent of these was that with regard to the existence of a penetrating neutral radiation which would give rise to penetrating mesons in lead Experimental evidence put forward by W. Bothe was questioned by Bruno Rossi and by Pierre Auger An hour's discussion of the point by the various investigators showed that further information is needed before the question of the existence of this neutral penetrating radiation can be considered confirmed

The only other question of major disagreement was that of the name which should be applied to the particle of intermediate mass This has been called at various times a heavy electron, a barytron, a yukon, a mesotron, a mesoton and a meson A poll of the assembled experts showed an approximately equal number favoring the name mesotron and meson. Partly because the European investigators seemed unanimously to favor the word meson, the present writer is likewise adopting that word in order to prevent the confusion of tongues

The accomplishments of the symposium are not to be measured in terms of definite new conclusions which were reached Its main significance lies rather in the fact that it focussed attention on the important possibilities of the study of cosmic rays The true effects of the conference will thus not be felt until those who were present have had time to express in their own work their reaction to the new ideas and the stimulating discussions

A H Compton

University of Chicago

THE STANFORD UNIVERSITY SYMPOSIUM ON THE CELL AND PROTOPLASM

It is seldom that I have attempted to write anything, however brief, which seemed to bristle with the difficulties that I now sense in acceding to the request of The Scientific Monthly for a report on this symposium To any in attendance the difficulties would not be hard to visualize. But first let me describe in a very general and, I fear, a rather superficial fashion the intent and form of the symposium

It was organized by Professor C V Taylor, dean of the School of Biological Sciences, and his immediate associates

with the purpose in mind of commemorating in appropriate fashion one of the great epochs in the history of the biological sciences — Schleiden and Schwann's enunciation of the cell theory As is true of scientific discovery generally, this basic concept did not spring in adult stature from the head of a single Zeus Many biologists, some of whom have been almost forgotten in the flight of the centuries, contributed their part But without doubt it was Schleiden and Schwann who finally drew together the researches of their many predecessors and presented to the world of learning a final statement of the cell theory in a systematic and comparative form with a full appreciation of its fundamental implications One can safely hazard the thought that had Schleiden and Schwann not been in a writing mood in the year 1838, others would certainly have presented the same theory in an equally or perhaps an even more acceptable form within a year or two The fruit was ripe and it was only a question of seeing the trees, recognizing the maturity of the fruit and picking the crop I have never ceased to be enraptured by the constantly recurring observation that most of our great discoveries in science are announced almost simultaneously from several different laboratories by men whose approach to the problem has been entirely independent However, the explanation is simple, for it is all a part of the endless process of the evolution and fruition of thought To those of us in attendance at the symposium evidences of this simple fact came again and again

The introductory address, historical in character, was presented by Professor E G Conklin, of Princeton University Unfortunately space does not permit us to speak of this in detail nor of the fifteen addresses that followed in the next five days Perhaps it is sufficient to mention that by a gradual transition we passed from consideration of the grosser structure of living things to a treatment of developmental and environmental factors, to microorganisms, over the bridge which possibly stands between the animate and the inanimate—the viruses, on to the active constituents of living things and finally to the larger molecules resident in protoplasm

It is fortunate that the papers will be published (as a monograph by the American Association for the Advancement of Science) so that it is needless to do more

THE SCHOOL OF EDUCATION BUILDING (RIGHT) WHERE THE STANFORD SYMPOSIUM CONVENED

MEMBERS OF THE SYMPOSIUM ON THE CELL AND PROTOPLASM

Back row ALBERT TYLER, WILLIS H JOHNSON, C H DANFORTH, E G CONKLIN, R G HARRISON ROBERT CHAMBERS, A J HAAGEN SMIT, V C TWITTY, W M STANLEY *Front Row* L V HEILBRUNN, C A KOFOID, H S JENNINGS, S C BROOKS, C M CHILD, A SZENT-GYORGYI, D M WHITAKER, L R BLINKS, C V TAYLOR RICHARD GOLDSCHMIDT, E W SCHULTZ

than mention the speakers by name E G Conklin, Robert Chambers, I W Bailey, H S Jennings, Richard Goldschmidt, C M Child, R G Harrison, C A Kofoid, C B van Niel, W M Stanley, H Theorell, F W Went, A Szent-Gyorgyi, O L Sponsler, L V Heilbrunn, J. D Bernal

By still another easy transition the meetings, born out of the Stanford University meetings of the Pacific Division, American Association for the Advancement of Science, passed on into the sessions of the National Colloid Symposium, which followed immediately after

One outstanding result of the symposium was to leave with all of us a vivid impression of the essential unity of the sciences It is all too easy for us, when surrounded by increasing evidence of diversification and specialization in research, to mumble the disheartening and misleading phrase, "more and more about less and less" Seldom have I taken part in a scientific meeting where one was made more acutely aware of the striking interdependence of all the sciences Biologists, chemists and physicists, speaking the same language, drew fully upon the resources of each to gain a deeper understanding of the world of nature

From it all I believe that we gained several suggestions of very great value that the animate and the inanimate constitute a continuum, that the concept of structure, so long applied to the atom, to the molecule, to the cell and to the organism, may well be extended to the society in which we are but structural units, that whether we be molecules or men we are what we are and we do what we do because of two fundamental factors—our innate qualities and our environment I would not dare to suggest that this exhausts the list of significant gleanings, but to me they constitute the

"Biology and its Makers" 1910 Henry Holt & Co

THEODOR SCHWANN, 1810–1882

MATTHIAS JACOB SCHLEIDEN, 1804–1881

most impressive contributions of the symposium

And now to conclude with less tangible and perhaps rather sentimental considerations Some of us who still like to think that we are numbered among the younger generation of biologists and biochemists will not soon forget the stimulating contacts and refreshing experiences that were ours as we saw, heard and chatted with the distinguished elder statesmen of science (younger statesmen also) and shared our lot with our many countrymen and visitors from abroad Unquestionably, this was probably the most memorable scientific gathering that we have known on the Pacific Coast and it is to be hoped that the bridge now reaching to the Atlantic Coast and Europe will bring to us many fresh contingents of our fellow scientists

The meetings steadily increased in attendance as the week progressed until, as the last day was reached, the facilities of the large Memorial Theater had to be drawn upon The periods of discussion which followed the papers were lively and vigorous I think they would have been a delight to Schleiden and Schwann and to the host of others whose contributions to science constitute the warp and the woof of such symposia

J. MURRAY LUCK
STANFORD UNIVERSITY

THE CENTENARY OF T. J. BURRILL

ON April 25, 1939, the one hundredth anniversary of the birth of Thomas Jonathan Burrill was celebrated by the University of Illinois, where practically his entire professional life was spent During his long connection with the university, from 1868 to 1912, he served in various administrative capacities, published the results of numerous researches, and carried at times a heavy teaching schedule Under him were developed a number of students who won recognition in various fields of botany, some of whom are still active

Burrill was born in Pittsfield, Massachusetts The family moved to Illinois when he was nine years of age He helped his father on the farm, attending and later teaching school during the winter months, he prepared for college at Rockford High School, which he entered at the age of 20, and graduated from the State Normal University in 1865

During the period from 1865 to 1868 Burrill held the position of superintendent of the Urbana public schools During the summer of 1867 he acted as botanist accompanying Major John W Powell on his expedition to explore the Grand Canyon of the Colorado and surrounding regions In 1868 Burrill was called to the Illinois Industrial University and in 1870 was made professor of botany and horticulture

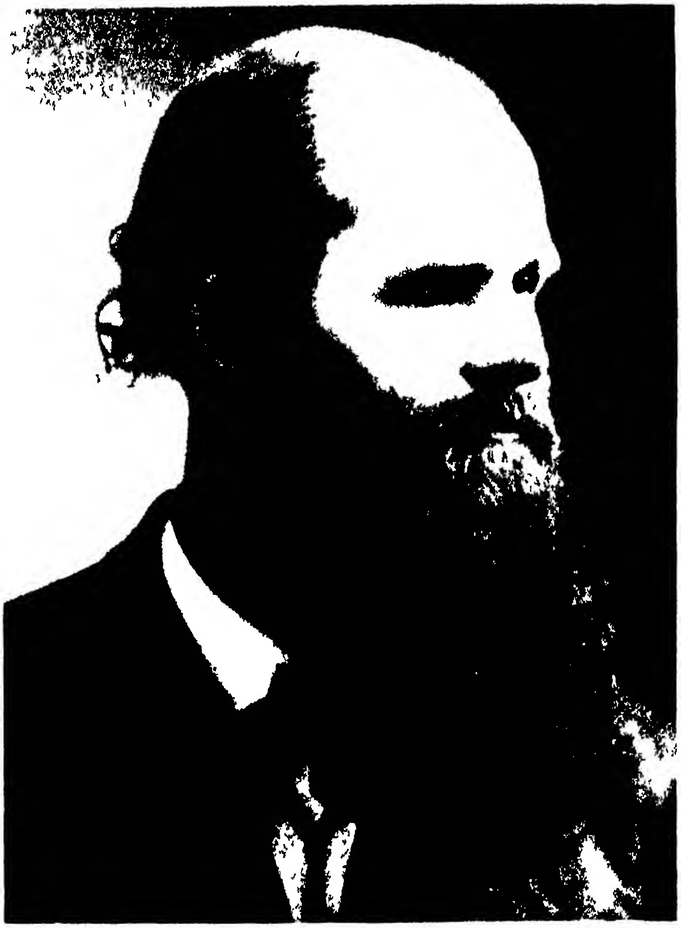
Regarding his activities in the early days of his service in this institution, now the University of Illinois, a friend is quoted as saying

> He taught most of the days, was horticulturist to the experiment station, planted with his own hands or saw to the planting of most of the trees on the campus, after he had laid it out for treatment, wrote reports, lectured here and there, served on innumerable committees, collected specimens up and down the state, and, lest some moment of his time should be unoccupied, was charged by the board with the sale of mules, whose labors on the south farm showed that they were not so able to stand the strenuous life as he was

Two notable contributions to the teaching of botany are to be definitely credited to T J Burrill He was the first to teach plant pathology, which he took up as part of his course in botany as early as 1873, two years before Farlow at Harvard, and he was the first in this country to use the compound microscope

in teaching undergraduate courses in botany

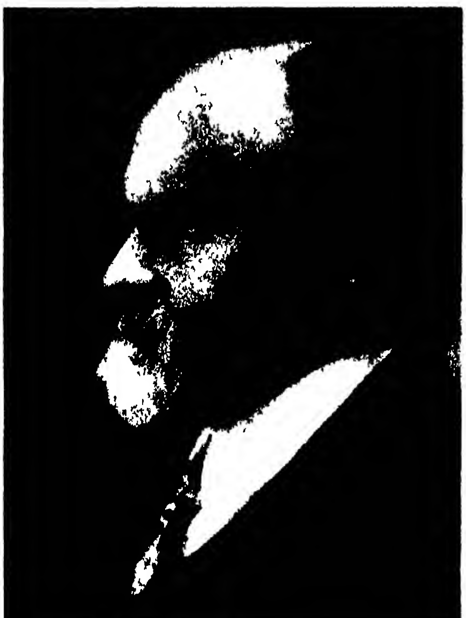
Burrill's great contribution to science, the discovery and demonstration of the first bacterial disease of plants, came as a result of patient and thorough work on what was then a major problem for the fruit-growers of his state The "blight" of pears and apples had been the subject of much concern and speculation for many years In 1878, just ten years after his first connection with the university, he presented to the state horticultural society a paper reporting his preliminary studies, in which he described the organisms seen in the tissues as "minute oscillating particles" The next year he reported his success in transmitting the disease by transferring the exudate from diseased plants to the bark of healthy trees In the report he used, though with great caution, the word "bacteria," adding "Does it not seem plausible that they cause the subsequent apparent change? So far as I know the idea is a new one—that bacteria cause disease in plants—though abundantly proved in the case of animals"



THOMAS JONATHAN BURRILL

Further careful work followed, and in 1882 the bacterial organism was described and named In subsequent years he worked on several other bacterial dis-

FRANKLIN SUMNER EARLE



ARTHUR BLISS SEYMOUR

eases and on various fungous diseases of apples, potatoes, corn and other crops. A cryptogamic flora of Illinois was projected and two monographs were published, one on the rusts and the other on the mildews.

It is fortunate for Burrill's reputation that he made this great discovery early in his connection with the university, for as time went on his energies were increasingly devoted to administrative and related duties. Of this Edwin F. Smith said with characteristic emphasis in an article published soon after Burrill's death:

> In America we have a peculiar way of treating all those who have demonstrated the possession of research ability of a high order, which may be designated as a method of extinction by promotion. As soon as a man becomes conspicuous through his researches, boards of control find other things for him to do, more in keeping with their ideas of efficiency and eternal fitness, and he ceases to contribute further except perhaps very indirectly, to the advancement of science. Professor Burrill was no exception to this rule.

During the first two decades of his connection with the university he made his great contributions to the science of plant pathology and trained four men who attained places of distinction in the fields of plant pathology and mycology, Earle, Seymour, Clinton and Waite. No attempt to detail the work of Burrill or any of the others is made here, since sympathetic biographical sketches[1] by personal friends are available for Burrill and three of his students. Although the fourth has been formally "retired" since 1935 there is happily little prospect of his becoming the subject of such a sketch for many years.

F. S. Earle, who was a student of Burrill's from 1879 to 1883, was at various times connected with the Kentucky, Mis-

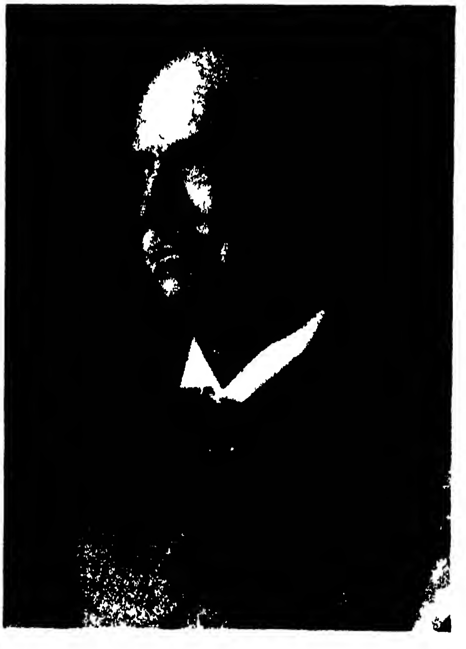
[1] Burrill, *Phytopathology*, 8: 1–4; Earle, *Phytopathology*, 20: 923–929; Seymour, *Mycologia*, 26: 279–290; Clinton, *Phytopathology*, 28: 379–387, and *Mycologia*, 30: 481–493.

sissippi and Alabama Experiment Stations, with the United States Department of Agriculture and with several institutions in Puerto Rico and Cuba More than once he engaged in commercial fruit production He is remembered both for his contributions to systematic mycology and as a leading authority on the diseases and culture of tropical plants

A B Seymour, who studied and worked with Burrill from 1878 to 1883, was essentially a mycologist So abundant were his collections during the period of his work in Illinois, and so carefully were they preserved that portions of them are still used as "class material" by the Botany Department of the University of Illinois The greater part of his life, 1883 to 1933, was spent in the Farlow Herbarium at Harvard, and his chief monument is the "Host Index of the Fungi of North America," the first of its kind

GEORGE PERKINS CLINTON

G P Clinton was at the University of Illinois as a student and investigator from 1886 to 1900 He followed Seymour to Harvard and in 1902 became botanist of the Connecticut Experiment Station, which position he held until his retirement in 1937 Most of his scientific contributions are contained in the publications of that station From 1915 to 1929 he was also lecturer and associate in the Department of Botany at Yale This long residence in New Haven was broken by two major scientific assignments, one in Puerto Rico to study diseases of coffee, and one to Japan for the collection and study of parasites of the gipsy-moth



DR M B WAITE

M B Waite graduated under Burrill in 1887 and spent almost his entire professional life with the United States Department of Agriculture Here, he was for many years in charge of the work on fruit diseases In 1898 he made one

of the great phytopathological discoveries of all time, namely, that bacteria which cause plant disease may be carried by insects. Appropriately enough this discovery was made with regard to the same disease in connection with which Burrill had made his great contribution nearly twenty years earlier.

NEIL E STEVENS
UNIVERSITY OF ILLINOIS

THE SEVENTH ASSEMBLY OF THE INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

ONE of the most significant scientific congresses to be held in this country will be the Seventh Assembly of the International Union of Geodesy and Geophysics to be held in Washington from September 4 to 15 Over 500 delegates and guests are expected in attendance To date delegates will represent 23 countries and over forty universities, colleges and scientific institutions in this country

The International Union of Geodesy and Geophysics is composed of seven associations These seven associations are concerned with geodesy, seismology, meteorology, terrestrial magnetism and electricity, physical oceanography, volcanology and scientific hydrology Unlike the usual meetings of technical societies, the program of the International Union consists largely of reports of commissions, discussion of agenda and the adoption of programs of research in the various fields of geophysics involving international cooperation Many important communications of interest to geologists will be presented, however, and significant progress will be reported concerning investigations in the fundamental problems of the earth sciences, such as those dealing with structure of continents and ocean basins, gravity determinations and seismology George Washington University will be headquarters for the assembly

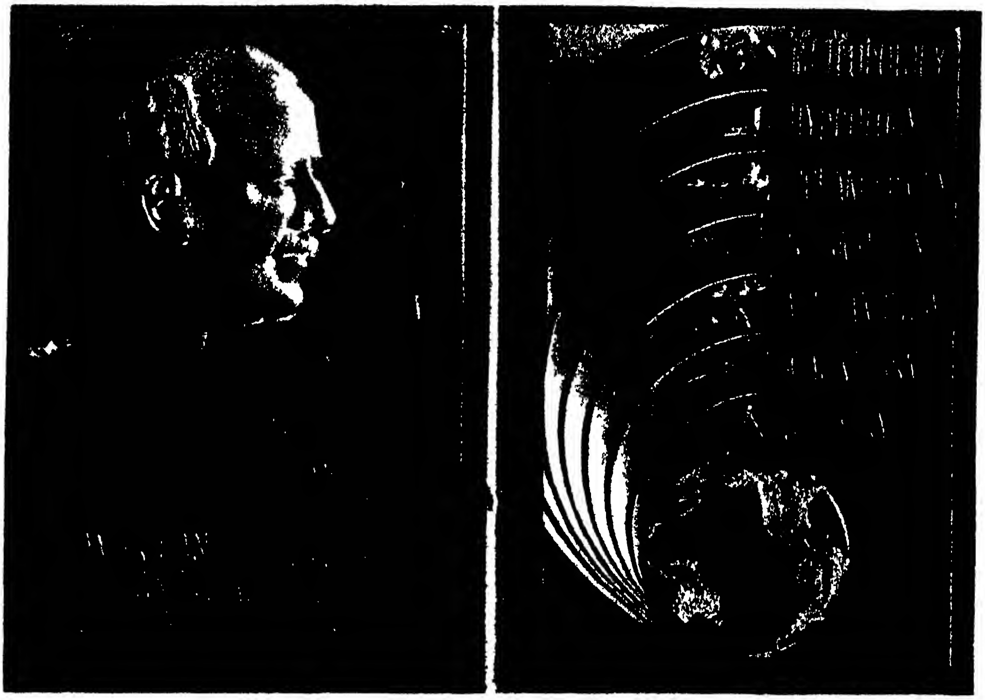
While there will be meetings of the several associations and commissions on Monday, Tuesday and Wednesday, the first general assembly, followed by a reception, will be held on Wednesday evening, September 6, at which the president, Dr D la Cour, will deliver an address

A public lecture by Brigadier-General H St John L Winterbotham, general secretary of the Union, on "Round the World with Geodesy" will be given on the evening of September 8 in the auditorium of the Carnegie Institution On the evening of September 13 there will be a public address in the hall of the Department of Commerce by Dr B Helland-Hansen, of the Geophysical Institute at Bergen, Norway, on "From the Mexican Gulf to the Arctic Sea—the Gulf Stream System and Its Significance"

The final general assembly will be held on September 16 in the new hall of George Washington University. The American Geophysical Union, with the cooperation of the National Research Council, are the official hosts for the Washington Assembly The arrangements for the assembly have been carried out through the work of nineteen committees and subcommittees The chairman of the organizing committee is Captain N H Heck, of the U. S Coast and Geodetic Survey

The meetings of the Union are held at three-year intervals, the last meeting being in Edinburgh in 1936 There is probably no scientific association that covers a wider field of interest than the International Union of Geodesy and Geophysics Perhaps in no other field are the problems of science so dependent upon international cooperation as in that of geodesy and geophysics

HARLAN T STETSON



WILLIAM BOWIE MEDAL OF THE AMERICAN GEOPHYSICAL UNION

THE WILLIAM BOWIE MEDAL

THE William Bowie Medal, endowed by friends and coworkers of Dr William Bowie, established by vote of the executive committee of the American Geophysical Union on March 1, 1939, in accordance with the deed of gift, is to be awarded for distinguished attainment and outstanding contribution to the advancement of cooperative research in fundamental geophysics The medal was designed by Margaret Fleming Nebeker, of San Francisco, and the dies were engraved by B Basch, of Washington The award of this medal is to be made annually or less frequently upon authorization by the executive committee of the Union

The first medal, which was struck off by the hydraulic press of the United States Bureau of Engraving through the courtesy of the director, A W Hall, was presented to Dr Bowie at the general assembly of the American Geophysical Union on April 28, 1939, by President Richard M Field In his citation President Field said

It is particularly fitting that the first award of this medal should be to the man whose name the medal bears It is not necessary here, among your intimate friends and colleagues in geophysics, to refer specifically to your long list of scientific accomplishments and honors But we do feel that in presenting you with the first imprint of this medal that has been created in your name, and that of the organization for which you have worked so long and so lovingly, we are not handing you merely a bit of stamped and engraved metal, but rather a powerful talisman of those human forces, affection, esteem and tradition so fundamental to the spirit of progress It is sincerely hoped that in the years to come this medal, through its future awards, will continue to promote and to recognize that spirit of helpfulness and friendliness in unselfish cooperative research which you have so bountifully displayed

SPECTROSCOPY IN THE REGION OF RADIO FREQUENCY

An extension of the field of spectroscopy down to the region of radio frequency has been developed by a group of physicists at Columbia University The group consists of Dr J M B Kellogg, Dr P Kusch, Dr S Millman, Professor I I Rabi and Mr Norman F Ramsey, Jr, all of Columbia, and Professor J R Zacharias, of Hunter College This development, which has taken place over a period of two years, has reached the point where accurate spectroscopy can be done on lines the frequency of which is less than a thousandth of the natural frequency width of ordinary spectral lines.

This new field of micro-spectroscopy can measure energy intervals which are 10^{-5} of the smallest energy intervals measurable by ordinary optical spectroscopy

In the new method the effect of the radiation is observed not by analysis of the radiation but by observing the effect on the atom or molecule This is made possible by the use of atomic and molecular beams A narrow stream of atoms or molecules limited by slits 01 mm wide is bent first in one direction by means of an inhomogeneous magnetic field, and later by means of a second such field, oppositely directed, is bent back again to strike a detector which is capable of measuring the number of atoms which reach it The second bending will just balance the first, provided the atom or molecule of the beam is in the same state in both fields If, however, in the region between the two magnetic fields the atom or molecule should undergo a transition to a different state, one bending will not cancel the other and the beam will miss the detector A transition in state can be brought about if the atom or molecule absorbs or emits energy In these experiments the atoms or molecules are caused to absorb energy from, or emit it to, an oscillating magnetic field between the two inhomogeneous magnetic fields, this absorption or emission taking place only at very definite frequencies of the alternating field corresponding to frequencies of the atomic or molecular systems The spectrum "lines" correspond to the field frequencies which cause the beam to miss the detector These frequencies in the experiments are in the range of short and very short radio frequencies

If a constant magnetic field is superimposed on the oscillating field the Zeeman effect of the lines can be studied

This method has been applied to the accurate measurement of the magnetic moments of a large number of nuclei, including the proton and the deuteron, the isotopes of lithium, beryllium, the isotopes of boron, nitrogen and other nuclei These measurements compare in directness and accuracy with measurements that may be made of the magnetic moment of an ordinary permanent bar magnet They arrive at results that lie far beyond the reach of ordinary spectroscopic methods An important result of the experiments with the hydrogen, deuterium and hydrogen deuteride molecules has been the discovery that the deuteron is not spherically symmetrical in shape but elongated along the spin axis

I I Rabi

Columbia University

THE SCIENTIFIC MONTHLY

OCTOBER, 1939

DOES SCIENCE AFFORD A BASIS FOR ETHICS?

By Dr. EDWIN G CONKLIN

EMERITUS PROFESSOR OF BIOLOGY, PRINCETON UNIVERSITY

I

In attempting to answer the question—"Does science afford a basis for ethics?"—it will be desirable to deal first with the theoretical and then with the much more serious problem of practical ethics *Is ethics natural or supernatural in origin?* That is the key question. When I was a student in college we were taught the supernatural origin of man Mind, language and especially ethics were gifts of God by which man was sharply distinguished from all other animals A few years ago the students at Princeton University staged a debate between myself and a professor of a theological seminary on the subject of evolution. It was at the time when William Jennings Bryan was stirring up the country on the dangers of evolution. There was a good deal of keen sense on the part of Mr Bryan in this, for he recognized that the doctrine of human evolution was striking right at the traditional view that man was above nature, whereas evolution was teaching that man was a part of nature, and that he had come into existence by natural processes

In this debate which the students had staged between me and the theological professor, I spoke first on the evidences of organic evolution and that of man in particular, but when my theological colleague rose to speak he surprised me and the audience by saying that he had no objections to offer to my argument; he was willing to let the biologists deal with the origin of man up to the time when man became a free moral agent There, in his belief, natural evolution ended and supernatural causes entered This is the position of many liberal theologians today, but while their recognition of the evolution of lower forms of life and of the body of man is gratefully acknowledged by the scientists, the final introduction of the supernatural does not satisfy the naturalist To the thorough-going scientist "Nature is everything that is," and the evolutionist finds abundant evidences of the natural origin of mind, language and even of ethics Indeed, even the supernaturalists in these evil days of crises attribute the ethics of some modern peoples and nations to the devil rather than to God, whereas the naturalists, if they are genuine naturalists, ascribe both good and bad to nature

There is positive evidence that in times long past there were types of human and partly human beings that were more brutish in body, mind and social relations than the general average of the present races There is abundant evidence that ethics has undergone evolution no less than intelligence It has developed from its beginnings in a primitive family group through tribal, racial, national and international relations, from the ideals and practices of savagery to those of barbar-

ism and civilization, from the reign of vengeance and retribution, as shown in the ancient code "an eye for an eye," "a tooth for a tooth" and "whosoever sheddeth man's blood by man shall his blood be shed" This was the iron rule of retribution Ethics has proceeded from this to that highest conception of ethics embodied in the Golden Rule. But just as in physical evolution there are retarded or retrogressive individuals or races, so also in the development of ethical ideas some people and periods are far behind others and all fall short of their highest ideals

In this question of the origin of the mental and moral characteristics of man it is not necessary to go back into the distant past of evolution, for we can see in children to-day the development of the mind, the acquirement of language and the growth of ethical ideals Nowhere in this development is there a sudden introduction of supernatural factors If anything in the world is natural, the development of the body, mind and morals of a child is natural This is not to say that we understand all about nature, that there are no mysteries involved—indeed the more we know of nature, the more mysterious it becomes For all science knows to the contrary there may be in the whole of nature, from sands to stars, from germ cells to geniuses, a mental, moral, teleological, ethical substratum or medium in which all things exist and develop, but, if such there be, it also is a part of nature and not some foreign supernatural interference with the regular processes of nature.

II

Those who hold that nature can not accomplish what we see around us and feel within us have too poor an opinion of nature They forget or are ignorant of the marvels of development They contrast the most highly developed type of intellect, ethics and human personality with the lower forms of life or with inanimate matter and declare that "never the twain shall meet." Looking at the end product of any development it does seem incredible that it should issue from such simple beginnings, that a beautiful flower or butterfly or bird should have come from a germ cell If we did not know that it is true, it would be incredible that a microscopic egg cell could develop into an elephant or a man. Or, most wonderful of all, that geniuses like Socrates, Plato, Aristotle, Newton, Darwin, Pasteur, Shakespeare, Goethe, Beethoven, were once babies, embryos and germ cells and yet no one denies this It does seem incredible that reason, emotion, aspiration and ethics should develop out of such simple functions and processes as sensitivity, reflexes, trial and error, and yet these incredible things are actual facts that can be verified by any one who will take the trouble to investigate them

Similarly, it seems incredible that all the hosts of heaven and the furniture of earth should have come into existence by a process of natural development or evolution, and yet almost universally scientists hold this view, and more and more people accept it The evolution of galaxies and stars and solar systems, of the earth with its oceans and mountains, plains and rivers, of plants and animals and man himself, the evolution of all the chemical compounds found in nature and even the evolution of the chemical elements are plainly indicated by all the evidences available In short, evolution, like individual development, is a universal law of nature There is no creation out of nothing, *ex nihilo nihil fit*

Everything in the universe comes into existence by transformation rather than by new formation And yet in this process of transformation or evolution new properties appear as the result of new combinations of the same old elements for example, new combinations of protons and electrons give rise to new atoms; new combinations of atoms to new molecules; new combinations of molecules to new compounds. In a similar manner in

the living world new combinations of genes give rise to new chromosomes, and new chromosomes give rise to new types of organisms, so that we have this production of newness by the simple process of new combinations—what has frequently been called creative synthesis or creative evolution, or, more recently, "emergence" In the development of a universe, no less than of a man, new forms and functions appear as a result of these new combinations

Psychical development begins with differential sensitivity or the ability to respond differently to stimuli of different quality or degree For example, suppose one takes a single-celled protozoan, like a paramecium, and performs the simple experiment that is often used to show students the behavior of such an organism Some of these protozoa are put in a trough of water, one end of which is cooled by ice, the other heated by a flame, in a short time they are all gathered in the middle region As one watches an individual he finds that as it gets to the hot end it slows up, pretty soon stops and backs, and finally turns around by a series of movements and goes in the other direction until it gets to a region which, we will say, is uncomfortable (I don't know why we should deny that feeling to the paramecium), when it backs again, and so it keeps going back and forth, avoiding extremes of heat and cold and keeping in a middle region which is comfortable

Plants do similar things If a germinating bean seed, is pinned on to a cork sheet which is held in a vertical position and kept wet by water, the shoot starts to grow up and the root to grow down Then if the sheet is rotated through 90 to 180 degrees the shoot will continue to turn up and the root down until it will wind up into a spiral like a watch spring These parts of plants are doing what the animals do, they are responding differently to different kinds of stimuli or to the same stimulus when it is in different degrees, and they are responding in generally beneficial ways, they are moving in ways that are satisfactory and avoiding those that are unsatisfactory

Now such behavior is fundamental in all living things They follow or grow toward the satisfactory and avoid the unsatisfactory Here are the beginnings, the very elements of the psychic life and it is evidently based upon the ability to distinguish or differentiate between that which is satisfactory and that which is not, and to follow after the one and avoid the other And this very fact, this very principle of distinguishing or differentiating and choosing or following is the basis of wisdom in men as well as in animals and plants There is indeed a wisdom of animals and plants that is based upon the same fundamental principles as is the wisdom of human beings

In the psychic development of higher animals and man differential sensitivity gives rise to the special senses Tropisms or reflexes, which are fixed methods of response to stimuli, are linked together into instincts Conditioned responses that are often repeated become habits Effects of responses that are stored in the protoplasm are known as protoplasmic or organic memory, such as are seen in the training of muscles and nerves in learning to walk or talk or play games When one protoplasmic memory comes to be often associated with another and different one we have associative memory Any animal that can learn anything, as for example the association of the sound of a bell with the presence of food, has associative memory. Such memory is found only in animals with a nervous system Each of these steps in psychic development is an "emergence" to a new and higher level, and each new level makes possible further development to still higher levels

III

With increasing complexity of stimuli and responses, behavior becomes less rigidly fixed and is more variable. Every

biologist who has tried to demonstrate to a class what should happen under certain conditions is sometimes much disturbed because it doesn't happen Animals do not always behave as they "ought" to behave Their behavior shows some variability or modifiability, and is not fixed Recently the physicists have been telling us that even in physics things are not rigidly fixed Charles Darwin, of Cambridge, physicist and grandson of the great evolutionist, said in his vice-presidential address before the British Association,[1] that there is a certain fuzziness about all phenomena in nature—things are not absolutely clear-cut and sharp, but there is a certain variability Now this is especially true of living things, and this brings in the possibility of modifying behavior Instead of responding to stimuli in a purely mechanistic way, organisms seem to have a certain amount of freedom, which may be due to conflicting stimuli or internal states or previous experience

I can make this plain by telling the story of a bullfrog which we kept in our laboratory for several years When we first brought him in he was frightened whenever any one came near his aquarium, and he would go off in a dark corner and hide By gentle treatment and by holding up buzzing flies on forceps, we could induce him to come forward and grab the fly, after which he would go back once more We could actually see in the behavior of this frog the balancing of opposing stimuli The stimulus of hunger led him to come forward, fear would cause him to retreat Finally when he found no harm in coming forward he would come to the front of the aquarium whenever any one came near He had learned to control his fear, and there had ceased to be any inhibition in his responses to the stimulus of hunger

In this way a certain amount of freedom comes about, and freedom is invariably measured by the extent to which remembered experience influences behavior Remembered experience is what we call intelligence or, rather, intelligence is this capacity of profiting by remembering experiences. Reasoning is only intelligence of a higher sort, where we deal with things in general rather than with specific instances Let me illustrate this distinction between intelligence and reason On the farm where I was brought up we used to have a horse that had learned the trick of opening a gate He knew just how to do that, he didn't make any mistakes once he had learned He was just as intelligent as I was in opening that gate He had learned by experience to lift the latch and let himself out But when we put another kind of a fastener on the gate, he was lost he couldn't reflect as a man could, "Now this after all is a mechanism for fastening the gate and it must have certain qualities similar to the old latch that I am acquainted with" He could not do that, he had to learn it all anew He was not able to generalize Reasoning is the power of generalizing, of comparing things and seeing certain resemblances that are fundamental, and ruling out those things that are accidental Reasoning develops in the life of the human individual from these simple beginnings

Of course, there are many other things that go into physical and psychical development, such as food, vitamins, hormones, etc In the construction of any building there must be materials such as bricks and mortar Likewise, in the building of the body and mind there have to be carbohydrates, fats, proteins, enzymes, hormones and vitamins, and they play a very important part, but they are only the bricks and mortar that are used by the particular forms of protoplasms and cells that are building the body and all its functions by the process of differentiation and development

[1] C G Darwin, "Logic and Probability in Physics," *Nature*, Vol 142, August 27, 1938

IV

In general, development is a gradual process, but we recognize that there are stages when it passes from a lower level to a higher level by the process of emergence. Finally, the highest level of human development is attained when purpose and freedom, joined to social emotions, training and habits, shape behavior not only for personal but also for social satisfactions, for *society no less than the individual is seeking satisfactions,* and when all these things combine, we have what we call ethics, or the science of right conduct. Thus ethics is born and man becomes a free moral agent—not absolutely free, of course, nor absolutely moral, but an agent of limited capacity and responsibility, who has developed under natural laws from a condition which is neither free nor moral nor responsible.

Since ethics depends upon training and habits as well as upon heredity and development, its approved codes vary from time to time and among different peoples and races. What is regarded as a high type of ethics in one race or age is wholly condemned in another. And in general there has been throughout the course of human history an evolution of ethics from relatively simple and crude and local types to more complex and refined and universal ones.

Here, in brief, is what may be called the scientific idea of the origin of man—of his body, mind and morals—and it is in sharp contrast to the traditional view of the supernatural origin of all these. Many persons, even many scientists, have assumed that since all this development is the result of natural processes it has degraded man, debased reason, destroyed freedom, debunked ethics, and last of all, eliminated God. In his condemnation of evolution old Thomas Carlyle said: "I have known three generations of Darwins, atheists all." It is interesting that he knew Erasmus Darwin, the grandfather of Charles Darwin, Robert Darwin, the father, and finally, Charles Darwin himself, the great evolutionist. If you will read the "Origin of Species" by Charles Darwin, you will see that in the last paragraph of that book he says, "There is grandeur in this view of life, with its several powers, having been originally breathed by the Creator into a few forms or into one." I merely bring that out to show that after all Charles Darwin wasn't necessarily an atheist, in spite of Thomas Carlyle, who continued: "Ah! it is a sad and terrible thing to see a whole generation of men and women wandering about in a purblind way and finding no God in this universe. And this is what we have got, all things from frog spawn, the gospel of dirt the order of the day." Carlyle didn't know much about frog spawn and the wonders of development. Apparently he didn't realize that the greatest human geniuses have developed from germ cells. Evolution is no more atheistic than individual development, and certainly neither of these has destroyed human freedom, responsibility nor ethics.

Darwinism, which is the doctrine of natural selection, or the survival of the fit, has been supposed by many people to be adverse to ethics. Bernard Shaw said that if Darwinism were true, only fools and knaves could bear to live. The survival of the fit and the elimination of the unfit meant to him, as it meant to Nietzche, Bernhardi and militarists in general, the survival of the strong, the ruthless, the people that are feared rather than loved, and conversely, the elimination of the meek, sympathetic and peace-loving. But this is a total misconception of Darwinism. Darwin was too wise a man to lend his support to any such extension of his principle to the social and moral fields. He knew, of course, that *there are many kinds of fitness* in human beings. There is not only the fitness of physical strength to be considered but also the fitness of mind and of moral and social conditions, and

Darwin said it is altogether wrong to attempt to force upon moral and social conditions the same standards that apply to physical conditions. Physically, the fittest are those that are most capable of living and leaving offspring. Sometimes they are strong and ferocious and sometimes they are mere parasites. Mentally, the fittest are the most rational; socially, the fittest are the most ethical. To measure social relations or ethics by mere brute force and strength is to miss the whole fact that *man has had a three-fold evolution*. There has been an evolution of his body, an evolution of his mind and an evolution of society and his social relations; and while these principles are always balanced one against another and sometimes are apparently in conflict, nevertheless they do generally cooperate and bring about important advances along the whole line. We can't possibly subscribe to any doctrine that would merely bring about physical development of a human being and at the same time subordinate his intellectual or destroy his social development.

In conclusion, evolution does not destroy the dignity of man. His real dignity does not depend upon the method of his origin; it does not depend upon the fact that he was once a germ cell and then an embryo and then an infant. *It depends upon what he is capable of becoming,* the possibilities of his development. There is where the real dignity of man is found. This is what makes him more dignified than the dog or the horse or the plant; he is capable of going farther in his development than these other living creatures.

Likewise, the importance of ethics is not to be measured by its humble beginnings nor by its present defects but by its possible developments and its influence upon human welfare. In all men, fundamental ideals of right conduct are much the same, but in practice these ideals are too narrowly limited. For example, the ideals of right conduct toward individuals who are closest to one, *e.g.*, toward one's children, are very much the same with all peoples of all races. Among some savage tribes there is no ethics or altruism that extends outside of the tribe: every tribe for itself and the devil take the others. Their altruism does not go further than that. As one goes up through higher and higher social grades one finds that altruism reaches farther and takes in more people, until with some persons it includes the whole human race. We feel sympathy for the people who are suffering in Europe and China. We feel resentment toward those who are making them suffer, because they are dealing with ethics in a small and local way instead of the larger and more general way toward which evolution is leading.

Science then affords a sound basis for ethics in spite of the fact that it is regarded as natural rather than supernatural in origin and development. It accounts for the fact that codes of ethics differ greatly among different peoples and in different stages of culture, which would be difficult to explain on any other basis than that of evolution. With increasing knowledge of nature and man many codes have been shown to be unreasonable and unethical, and science has helped to replace these by more rational and humane ones. Science is knowledge of nature and of man, and ethics is necessarily dependent on such knowledge; it is therefore impossible to divorce ethics from science. But science did not create nature or man or ethics and can not be held responsible for their imperfections. It is as absurd to attribute human greed, aggression, hate and war to science as it would be to hold it responsible for hurricanes and earthquakes and pestilences. It is because science regards ethics as a natural phenomenon that it can hope to determine the cause of unethical behavior and thus attempt to improve ethics by controlling those causes. This is the way in which progress has been made in the

control of bodily diseases and there is every reason to believe that it will be equally effective in controlling social disorders

V

When we come to consider practical ethics, we enter a veritable jungle of thoughts, opinions and beliefs, not founded upon real scientific and verifiable knowledge but upon the whole range of human emotions Following the example of the present alphabetical practice in which initial letters are used instead of entire names, Henshaw Ward has called such thoughts, opinions and beliefs "Thobs"

Practical ethics applies to every social relation from the sexual relations of men and women and the relations of parents and children to those between employers and employees, between capital and labor, between producers and consumers, between individuals and society, between classes and races and nations In all these relations there is ever present the selfish tendency to limit altruism to select or special groups and to regard all others as outside bounds There are professional and business codes, agricultural and industrial codes, union and non-union codes, and even bootlegger's and racketeer's codes Some of these are more generous than others in their treatment of those outside their particular group or class, but even the best of them, such as those established by the medical and legal professions, have been charged recently with disregard of public interest

Among nations and races this selfish tendency to take unfair advantage of others is wide-spread and generates the principal crises and tragedies of history Its most flagrant expressions of greed, aggression and war are eloquently denounced by many isolationists and superpatriots whose mottoes are, "Ourselves alone" or "My country, right or wrong," and whose ethics is essentially as selfish, narrow and ungenerous as that of the nations they condemn

The faults and failures of present social relations are almost universally recognized Revolutionists would

> Shatter this sorry scheme of things to bits
> And mould it nearer to the heart's desire

But generally the way of evolution rather than that of revolution is the way of progress Conflicts between democracy and autocracy, between anarchism and absolutism, between communism and fascism are conflicts of ideals in attaining the good society, and as such are ethical in aim, however mistaken they may be in practice It may seem incredible that hate, intolerance, murder, war should be employed to promote ethics, but the contestants always proclaim, and probably sincerely, their high ethical ideals They always claim to have truth, right, justice, even God, on their side, although they may employ the most inhuman methods in attaining their aims

Practical ethics is thus a jungle of conflicting emotions, ideals, practices, usually founded upon "Thobs" rather than upon established facts In an attempt to break paths through this jungle, innumerable ethical codes have been set up which are almost as varied as human relations themselves To promote justice and harmony among all these conflicting groups, governments are established among men and general codes are laid down in the form of laws Our laws are codes of ethics They are administered by courts of justice, which also deal with codes of ethics—all in the interest of better social relations But outside these major and minor paths through the jungle there are multitudes of personal relations which are not touched by codes or laws Probably no cause of social discord is equal to that of differing standards of ethics Violations of our personal ideals of honor and right conduct create resentment and anger Ethics or its violations fill our newspapers, occupy our legislatures and courts, concern our churches, distract our homes It was Matthew Arnold, I think, who said "Conduct is two thirds of life."

It is even more than that, it is almost all of social life

Probably the most important ethical and religious code in history is the Decalogue of Moses, which was summarized by Jesus in the two great commandments, "Thou shalt love the Lord thy God with all thy heart, soul, and mind, and thy neighbor as thyself" If for the person of Deity there be substituted the qualities of Deity, namely, truth, justice, mercy, love, these are the commands of science as well as of religion Likewise, the Golden Rule is the simplest and at the same time the most universally practicable rule of ethics ever proposed "Whatsoever ye would that men should do to you, do ye even so to them"

But organized religion, which should be and often is the most important school of ethics, has had, nevertheless, a bad record in provoking strife and war and in glorifying cruel and bloody practices Primitive religions have probably been the most unethical of human institutions as measured by present-day standards Their horrible practices of mutilation, torture and sacrifices to demon gods, or of throwing children to crocodiles or tearing out the throbbing hearts of human sacrificial victims were once considered supremely religious and ethical From such conceptions to those of the founders of the great religions of the present world is a long road, but it is distressing to remember the massacres and religious wars of so-called Christian nations, the torture chambers of the Inquisition with their thumbscrews, racks and wheels for disjointing bodies and all the instruments of torture that holy inquisitors could devise to save the souls of poor sinners

From our more enlightened standpoint we regard such horrible practices as revolting or insane and in general we can thank increasing knowledge of nature and of man for any progress that has been made toward their eradication But a candid examination of the ethics of thousands of people in what we call highly civilized nations leaves little ground for pride and satisfaction A vast deal of superstition still survives In certain great centers of population human beings of various colors are worshiped as gods, in others they attain only the rank of demi-gods In certain great nations science and truth are subordinated to political ideologies with as much ferocity as was ever shown toward heretics by the church Human sacrifices unparalleled in the past history of mankind are still made on the altars of patriotism Thousands of innocent non-combatants are blown to fragments or crushed and mangled in the ruins of their homes by bombs dropped from airplanes

Many persons are saying in these evil days that science has made possible the horrors of modern war and the question is seriously asked by thousands of people whether the invention of high explosives, poison gases, submarines and airplanes has not been a curse rather than a blessing Instruments of aggressive war may always be considered curses, but the scientific discoveries which made these possible are usually blessings In spite of the fact that its gifts and benefits have been abused by unethical men it is strictly true that science has made possible a "more abundant life" than mankind has ever known before, it has increased and improved our food, clothing and shelter, it has promoted health, long life and general welfare Whether science has actually increased human happiness depends largely upon the capacity of individuals for happiness, for as Burns so truly said,

> If happiness have not her seat and center in the breast
> We may be rich or proud or great but never can be blest

It is often said by critics of science that it has contributed only to the means of living and not to the ends and values of life But who in his senses will deny that a primary end of life is to live, and who

will deny that freedom from epidemics, improved health and expectancy of life, increased means of comfort, leisure and enjoyment are not values Most of all when we consider the decline of superstitions, such as witchcraft and demoniacal possession, and the growth of a sense of reality and natural law do we realize the fundamental contributions of science to practical ethics

But how cold and distant from the present crisis of civilization all this discussion of the basis of ethics seems! The imminence of another world war with the mass murder of thousands if not millions of victims and with the destruction of the fairest products of civilization calls for something more than a scientific or philosophic discussion of ethics What if anything can be done to ward off this terrible catastrophe? The very fact that it is recognized by the common people of all nations as a terrible ordeal is one of the most hopeful indications Science has helped to make war so terrible that sane people everywhere fear and shun it It has made war so costly that the conviction is wide-spread that a general war can never again be profitable More indirectly science can investigate the causes of wars and show how these can be removed, for wars and social disorders in general can be cured only as bodily diseases are, by controlling their causes

But the main hope for human peace and progress lies in the cultivation of the habits that make for peace and progress, especially in the leaders of the nations If these leaders dreaded war as much as most of the common people do there would be no more wars If the spirit of reciprocity were more wide-spread all forms of social conflicts would be lessened Biologically life is maintained by continual balance, cooperation, compromise, and the same principles apply to the life of society There can be no final solution of these problems which threaten the very existence of civilization except through the cultivation of a wider and more generous form of ethics This will be no short and easy task, but in the cooperation of science, education and religion there is hope for the future

THE INFLUENCE OF NUTRITION ON THE DISEASES OF MIDDLE AND OLD AGE[1]

By Dr. VICTOR G HEISER
NEW YORK, N Y

In the past the extraordinary success in liberating man from the pestilential diseases has been achieved largely in the field of environmental sanitation No great change has been required in man's personal habits. The engineer has provided him with safe water The human race has been saved from plague by protection against rat fleas Typhoid fever and cholera have also been controlled by environmental means Smallpox and diphtheria have been made puny enemies by vaccination, and malaria and yellow fever can be prevented by community effort Great as these victories have been, the knowledge for far greater conquests is already available The application, however, depends upon personal effort, and the question is, can this be brought about on a sufficiently large scale to equal or excel former achievements? History shows that at best progress may be slow In the past advance has been comparatively rapid because, broadly speaking, we have been dealing with things rather than with people. To induce man to change his personal habits requires extraordinary effort, either educational or compulsory, and compulsion does not achieve good results in modern democracies, as was well illustrated in our national prohibition law This means that we must place our main reliance upon education, which is a slow process beset with many difficulties But before stressing the difficulties in protecting mankind against suffering and untimely death, let us examine the evidence upon which the optimism for further progress is based That food has been associated with man's well-being goes far back into history Tales of gout and rich living abound in popular literature The little boy's belly-ache and green apples is an old story A number of the religions, with their hundreds of millions of followers, proscribe many foods The Hindus and the Seventh Day Adventists are vegetarians Pork is forbidden to the Mohammedan and the Hebrew The good Catholic eats no meat on Friday All this indicates a belief that human well-being can be promoted through dietary restrictions It was not, however, until our generation that scientific information became available, showing that definite changes can be brought about in the tissues of the body, many of which give rise to signs and symptoms that we have long recognized as disease entities, as, for instance, beriberi and sprue

Eijkman in Java in the early nineties produced polyneuritis in chickens. Funk, working in England a little later, ascertained that definite pathological states resulted when certain substances were missing from the diet The latter he called vitamins Since then progress has been rapid The steps leading to the discovery of the connection of polished rice with beriberi are as fascinating as a good detective story. Eijkman learned that polishing off the outer coat of rice before feeding it to chickens caused polyneuritis, but he was unable to isolate the specific substance in the polishings The discovery of the true cause of beriberi came

[1] Maiben Lecture, American Association for the Advancement of Science, Milwaukee, June 21, 1939

with the opening of the huge rubber plantations in the Straits Settlements and the Federated Malay States Chinese and Indian laborers were imported and promptly developed beriberi, thus threatening the entire industry. Two British scientists, Fraser and Stanton, attacked the problem with laboratory methods Entirely unaware of Eijkman's work, they arrived at the conclusion that beriberi was due to a food deficiency; that is, to the absence of certain chemical constituents necessary to the nourishment of the human body They ascertained that the essential factors were contained in the outer layers of the rice grain, but they also were unable to isolate the specific substance However, they soon learned that if rice were polished or ground so that it contained less than four tenths of one per cent of phosphorus pentoxide, such rice would cause beriberi, thus establishing a standard for safe and unsafe rice Tests were made with chickens, and then on inmates of the insane asylum at Kuala Lumpur The results in man and in chickens were the same; those who ate polished rice came down with beriberi or polyneuritis, and those fed only on unpolished rice remained healthy They then tried a further experiment A railway was being built in Malaya, and some 300 of the workers joined in the test Half were put upon a diet of unpolished rice and the other half on polished rice, the latter group came down with beriberi; then clothing was exchanged, beds and quarters occupied by the sick were occupied by the well, but those on unpolished rice apparently could not be contaminated, while those on polished rice remained sick even after they had been put into clean quarters The diet was then reversed, and gradually the sick became well and the well became sick

Beriberi, like malaria, is largely a man-made disease and has caused extraordinary havoc among the rice-eating peoples of the Far East It is conservatively estimated that in the Orient there are at least a million constantly ill with beriberi, and that 100,000 or more die from this disease annually The numbers are probably very much larger because of the intimate relationship of beriberi to infant mortality Until modern man invented a power rice-polishing machine beriberi was comparatively rare because the effort was too great to polish rice by hand

During my early period as director of health for the Philippine Islands we had about 1,000 deaths a year from beriberi among persons who were subsisted by the government, that is, among prisoners, insane, sailors, lighthouse keepers, etc We tried every imaginable treatment, but with very little success As soon as Fraser and Stanton announced their discovery it was immediately tried on a small scale in the Philippines The outcome was so promising that the governor-general issued an executive order requiring the use of unpolished rice in all government institutions The effect was magical In a few weeks no new cases appeared and those not seriously ill began to recover As long as this executive order was enforced there were no further cases, and the rate of 1,000 deaths a year dropped to zero Similar steps were taken with the diet of the Scouts, who were a part of the United States Army in the Philippines, and a similar result followed The same action was taken with the Javanese Army and in the jails of Hongkong, and beriberi quickly disappeared The health officer for Shanghai held doggedly to the infection theory and continued the diet of white rice and disinfecting the jails, and beriberi persisted as of old

Notwithstanding the tremendous educational effort that was made to bring the truth home to the Filipinos that beriberi

was due to a dietary deficiency, and notwithstanding that this educational effort has now extended well over twenty-five years, there has been small reduction in the number of beriberi cases among the general population This makes concrete evidence of the difficulty of applying proved knowledge when the effort interferes with the personal habits of individuals Man is often ruled by emotion, and he is frequently most illogical in his likes and dislikes

The Philippines probably had one of the highest infant mortality rates of any country in the world, it often reached 500 per thousand The attention of Allan J McLaughlin and Vernon Andrews was attracted to the unusually large number of infant deaths ascribed to bronchitis, pneumonia, heart disease and an illness among children locally known as "taon" Through a series of autopsies they established that the principal cause was beriberi, and this in turn occurred most frequently among breastfed infants Investigation of the diet of the mothers showed that they lived largely on polished rice and dried fish As educational efforts had largely failed to induce the general population, and especially the mothers, to use unpolished rice or add accessory food substances to their diet in order to make up for the deficiency in the rice, Vedder and Chamberlain, two Army officers serving on the United States Army Tropical Disease Board in the Philippines, conceived the idea of making an extract of the rice polishings and feeding this to children of mothers who were obviously not properly fed Their resolve was strengthened by observing that fighting roosters fed on rice polishings (or tique tique) grew strong and robust In many cases the result again was almost magical A child who had been irritable and fretful, crying much of the time and not gaining weight, almost within twenty-four hours after the administration of this rice extract would fall into a quiet sleep, rapidly gain weight and soon become normal The Philippine Government spent huge sums in making this rice extract available, and the remedy was no doubt an important factor in reducing infant mortality But if the people could only have been induced to employ prevention instead of cure, how much better the results would have been!

The case of beriberi is thus stated in more or less detail in order to show the extreme difficulty in bringing about the application of a discovery that requires a change in food customs We cannot comfort ourselves with the thought that this only occurs among the illiterate hordes of the Orient Knowledge such as this is available for the prevention of many of the diseases from which we suffer in enlightened countries like the United States and Europe

We are having a similar experience in this country with pellagra From 3,000 to 5,000 deaths occur in our own South every year, and thousands upon thousands are made ill with this disease It has been conclusively demonstrated that pellagra belongs to the deficiency group and occurs most frequently among those whose staple articles of diet are hominy, pork and molasses These food substances do not contain the necessary ingredients to keep the body in health It has been shown that those who have a vegetable garden and use the produce regularly never suffer from pellagra Notwithstanding the extraordinary educational effort that has been made to bring these simple truths home to people of our South, pellagra still occurs in discouragingly large numbers

The foregoing shows the tremendous importance of food in the causation of several diseases in the field of internal medicine I wish now to adduce evidence

that great opportunities also beckon in the field of surgery, and that the possibilities for prevention are as great as those in the sphere of the internist

Sir Robert McCarrison established in India a thoroughly healthy rat colony. The animals were regularly exposed to sunshine, cages were sterilized with creosol solution, the animal room had tiled floors, and the walls were frequently whitewashed In a room that had over 500 rats the casual visitor was unaware of their presence through the sense of smell Under these conditions McCarrison kept over a thousand stock albino rats The pairs were kept in roomy, netted-wire cages, screened and straw-filled, in which they found peace and the necessary comfort for fruitful breeding As a rule, five or six litters were taken from each pair The older animals were thinned out at the age of two years, which is a life span corresponding approximately to 40 to 50 years in man The average number of a litter was eight, although twelve to fifteen were common The mothers invariably reared all their young The stock rats were fed a diet similar to that eaten by certain peoples of Northern India, among whom are some of the finest physical specimens of mankind The diet consisted of whole-wheat flour, unleavened bread lightly smeared with fresh butter, sprouted Bengal gram (legume), fresh raw carrots and cabbage ad libitum, unboiled whole milk, a small ration of raw meat with bones once a week, and an abundance of water During two and a quarter years there was no illness among these rats, no deaths from natural causes occurred in the adult stock, and there was no infant mortality McCarrison made autopsies in 1,189 of these rats, which ranged from infancy to two years The only disease discovered was an occasional cyst in the liver containing tapeworm larvae. This infection probably came through nibbling the straw bedding Both clinically and at post-mortem examination the stock was shown to be remarkably free from disease In a control group of a similar number the same scrupulous cleanliness was maintained The animals were exposed to the sun's rays, they lived in separate cages the same way as the controls in each experiment, they differed from the other animals solely in their food Here again effort was made to feed them the diet of the people of India, among whom disease was very prevalent and defective stature was common Of these improperly fed rats, 2,243 were examined at post-mortem The following is a list of the lesions found

Chest pneumonia, bronchiectasis, pyothorax, pleurisy and haemothorax
Ear otitis media (this very common)
Nose sinusitis
Upper respiratory passages adenoid growths
Eye corneal ulceration, keratomalacia, panophthalmitis
Gastro intestinal dilated stomach, gastric ulcer, epithelial new growths of the stomach, gastric cancer (two cases), duodenitis
Urinary tract pyonephrosis, hydronephrosis, pyelitis, renal calculus, ureteral calculus, dilated ureters, vesical calculus
Skin loss of hair, dermatitis, gangrene of feet and tails
Blood pernicious type of anemia
Lymph and other glands submaxillary cysts, enlarged and often abscessed inguinal glands, mesenteric and bronchial glands
Endocrine system lymphadenoid goiter, enlarged adrenal glands, atrophy of the thymus
Nerves polyneuritis
Heart atrophy, myocarditis, pericarditis, hydropericardium
Teeth mal occlusion and a large percentage of decay

The ill-balanced diet associated with these diseases consisted mostly of cereal grains, vegetable fats, with little or no milk or butter or fresh vegetables This diet was not expected to produce diseases of the bones and teeth. The exposure of the animals to sunlight probably compen-

sated for any lack of vitamin D in the diet. It will be noted that the foregoing list contains many diseases that are of interest to the surgeon—sinusitis, adenoid growths, otitis media, gastroduodenal ulcers, gynecological ailments, certain types of goiter and urinary calculi

As there were no adenoids among the control group, it is a fair assumption that in the other group they were due to faulty feeding, especially as a duplication of the experiment with vitamin A deficiency diet produced similar results. In McCarrison's rats these growths were observed mostly in the trachea He assumes that adenoids would also have been found if he had continued his serial sections into the nasal passages Otitis media was present in seventy of the defectively fed rats Ponfick reported that in 100 autopsies of English children under four he found 91 per cent had evidence of middle ear disease and in only 10 per cent was the condition recognized during life.

In the rat experiment just cited a number of cases of gastric and duodenal ulcers occurred There is further confirmation that they were directly associated with deficient diet It has long been known that gastric and duodenal ulcers prevailed extensively among the inhabitants of South India and particularly in Travancore and in Madras. With the hope of throwing light on the etiology, a group of albino rats was fed on a typical Travancore diet, which consists largely of tapioca root, rice, a little fish, red pepper and rice water In the adjacent province of Madras, gastric and duodenal ulcers are also common Accordingly another group of rats was fed upon typical Madrassi diet, which consists of rice, red pepper, tamarind, a little fish and congee or rice water In both groups the food was prepared the same as the human food In the Travancore group 27 7 per cent developed gastric ulcers and in the Madras group 11 1 per cent. These figures are said to compare with the relative incidence of gastric and duodenal ulcers in the general population. No ulcers in the intestinal tract occurred in the control group of rats fed on balanced diet.

In the gynecological field, research holds forth promising possibilities The rats on the one diet had no gynecological pathology Many of the rats on the second diet had inflammation of the uterus, ovaritis, death of the fetus in utero, premature birth—in brief, the conditions found were the result of keratinization of epithelial cells, which follows the use of vitamin A deficiency diets

McCarrison produced lymphadenoid goiter under experimental conditions. He also found that the administration of iodine to rats fed on diets deficient in fat-soluble vitamins may cause goiter His investigations in Switzerland led him to suspect that while no doubt a large percentage of the goiters in that country were due to the use of iodine deficient snow-water, yet there were many other goiters that apparently had a different etiology To test his hypothesis he used a group of rabbits as experimental animals Their cages were not cleaned, and gradually a foot or more of the droppings accumulated on the floor Upon this he sprinkled water and caught the filtrate This substance he called noxa, for want of a better name, and fed it to the rats, and a considerable percentage of them developed goiter

Another significant experience has been recorded in connection with stone in the bladder Estimates based on hospital statistics show that the incidence of stone in some of the northern provinces of India is at least 438 per hundred thousand; conservative estimates place the incidence very much higher The first stones produced in white rats by diet were observed by McCarrison incidental to an experi-

ment to learn the effect of an iodine-poor diet upon the thyroid The diet consisted of oatmeal 53 parts, linseed oil 20 parts, corn flour 25 parts, calcium phosphate one part, and distilled water ad libitum After 157 days, among 120 experimental rats, stone occurred in 17½ per cent. In a subsequent experiment the oatmeal was replaced with whole wheat and the incidence rose to 22 per cent As lime was added to the diet the incidence rose still higher. No case of stone occurred in the control group of rats When two thirds of an ounce of whole milk was added daily to the deficient diets no stone occurred in any of the rats Butter and cod-liver oil had a like effect The vegetable oils did not prevent stone The incidence of stone in rats can also be reduced, if a defective diet is rich in lime, by adding sufficient sodium phosphate to form with the excess lime insoluble calcium phosphate An analysis of 226 human urinary calculi showed that over two thirds of them were either urate-oxylate or urate-oxylate-phosphate Pure uric acid stones occurred in 6 per cent of the cases The stones experimentally produced in rats were of four kinds ammonium-magnesium phosphate, calcium carbonate, calcium hydroxide and a mixture of the last two By alternately withholding and then adding vitamin A, the chemical composition and stratification of the stones in rats were identical with those occurring in cattle under natural conditions McCarrison showed me a number of cattle stones from which it was quite easy to divide up the year into rainy and dry seasons by studying the stratification

While in Japan a few years ago I found Professor Saiki, director of the Imperial Government Institute for Nutrition, in the midst of an experiment in connection with the healing of appendix operation wounds He obtained permission to prescribe the diet of hospital appendix cases after they had been operated upon The data indicated that with certain changes in the diet, and particularly by regulating the ingestion of vitamin A, he could accelerate the healing or prolong it almost indefinitely Saiki's assistant, Fujimaki, produced gastric ulcers in rats with defective diet, and if this was sufficiently prolonged the ulcers became malignant Fujimaki also produced gall, kidney and urinary bladder stones in rats fed on defective diets

One of the most striking experiences in visiting McCarrison's laboratories was to see his post-mortem specimens of the stomach and intestines of monkeys and rats that had been fed on defective diet These organs were thin and translucent, the stomach was dilated, and many loops of the intestines were ballooned There had obviously been structural changes in the tissues In surgical clinics I have seen resections of such loops How futile this appears in the light of this newer knowledge Ulcerative colitis was also very common in these animal specimens. This condition is frequently observed among the residents of Madras who live on diet that was found deficient for rats Keratomalacia was also frequent among these people In brief, there is much evidence to show that diets deficient in vitamin A cause changes in the epithelial cells, which in turn are unable to resist bacterial invasion and many pathological conditions occur with which we are familiar McCarrison has shown, and with much confirmation by Lloyd Arnold and his coworkers, that bacterial invasion may follow chemical and physical changes in the intestinal tract, that if rats are fed on vitamin A deficient diets and are then artificially infected with paratyphoid organisms, they usually die from the resultant infection Among those that live the paratyphoid infection may persist in the lymph glands for con-

siderable periods after the general infection has been overcome It also seemed probable that chronic enlargement of lymph glands in childhood may be due to infection of one kind or another that entered through defective fences brought about by deficient diet

On an occasion such as this I am of course unable to give more than a few examples of those who have contributed so much in the field of nutritional research

The foregoing evidence shows the close association between the importance of diet in the preservation of healthy cells and tissues with consequent normal function The rat experiment by McCarrison demonstrated that no disease whatever appeared among rats correctly fed, and that apparently many of the usual diseases that are encountered in a doctor's office or hospital clinic could be induced in healthy rats by improper feeding There is, however, an additional factor which has been much neglected in the application of nutrition studies to man The right balance of constituents in his diet are most important, but it is also important that the digestive tract shall be in a healthy condition if the diet is to produce disease-free, sound bodies. All too often it happens that man's digestive apparatus has been so deranged by years of wrong eating that even a correct diet is incapable of restoring him to normal It is therefore essential that the intestinal tract be put into good condition, as well as to have the correct diet There is also an economic aspect Correct eating involves a much lower outlay for food than the customary menus If a diet is correctly balanced a smaller quantity of food will suffice This is of course obvious For instance, if we poured an excess of lubricating oil into a motor, it would not cause the engine to function any better. All too often we eat far too much of a substance that is not needed, and still suffer from hunger if a needed substance is not present in sufficient quantity. There is every reason to believe, then, that the nation that can regulate its food consumption in accordance with scientific principles may not only produce a larger percentage of sound healthy people, but at a cost infinitely less, and by inference become the leader of the world

NUMERALS ON CLOCK AND WATCH DIALS

By the Late Professor D. W. HERING

CURATOR OF THE JAMES ARTHUR COLLECTION OF CLOCKS AND WATCHES, NEW YORK UNIVERSITY

WHEN a new utility is in course of development patterns and designs for it are numerous and often fantastic, but if it is likely to be permanent its form is likely to be stabilized Thus, when the stage-coach gave place to the railroad car the latter underwent steady improvement in design but eventually took on a form that, in the main, was generally adopted throughout the world So, with vehicles generally according to the particular kind of transportation for which they were intended Such is the common experience in every order of industrial development It is not a matter of fashion, for fashions are adopted with a full expectation that they will not last long, whereas utilities look to permanency It is when a new mode of action is discovered, opening up new fields of operation, that invention is active and fancies are fanciful, as in the automobile, yet even this last has become fairly conventionalized in form

The same applies to the progressive development of timepieces Not only as whole classes of objects are clocks and watches of interest to collectors, individual features are distinctive enough to make a ground for a special collection, and of these features by no means the least interesting are the dials, which may be further specialized with reference to size, shape, color, artistic quality, material of construction and to the numerals on them These last offer an inexhaustible variety in size, form and position, but when studied in detail they can be classified to some degree In the progress of the timepiece, from the massive tower clock to the omnipresent wrist watch, besides the general form its component parts also were variously modified, and the face of the clock, like that of a human being, now conforms in general to a standard pattern but is infinitely varied in its separate features When a style has become established the designer who follows it is safe, but the moment he departs from convention he risks criticism and ridicule In a period of change fancies run amuck, and when he yields to the desire for novelty the results are sometimes ludicrous

ALPHABETIC NUMERALS

A country that has a language and literature of its own usually has its own form for the letters of its alphabet and for its numerals Most of the civilized peoples have now adopted the Roman form for text material, and Roman or Arabic for numbers, but not all, and with some the substitution of Roman for native or other earlier characters is comparatively recent In others both the native and the foreign are used, the German and the English are examples both employ the Roman but the former also retain their German type and for special purposes English peoples sometimes use the Old English or Black Letter The German and the Old English are monkish modifications of the Roman and are designated as "Gothic" though they are not like the Gothic font of type used in printing A national change in such usage touches the daily life of a people so closely that it can not be dissociated from the progress in the growth and development of the nation itself, it has, therefore, a wider significance than appears at first sight—a sociological significance

A change of that kind, though not so comprehensive, was effected in Japan in 1873 when the Western mode of daily time reckoning and time keeping displaced the system that had prevailed there

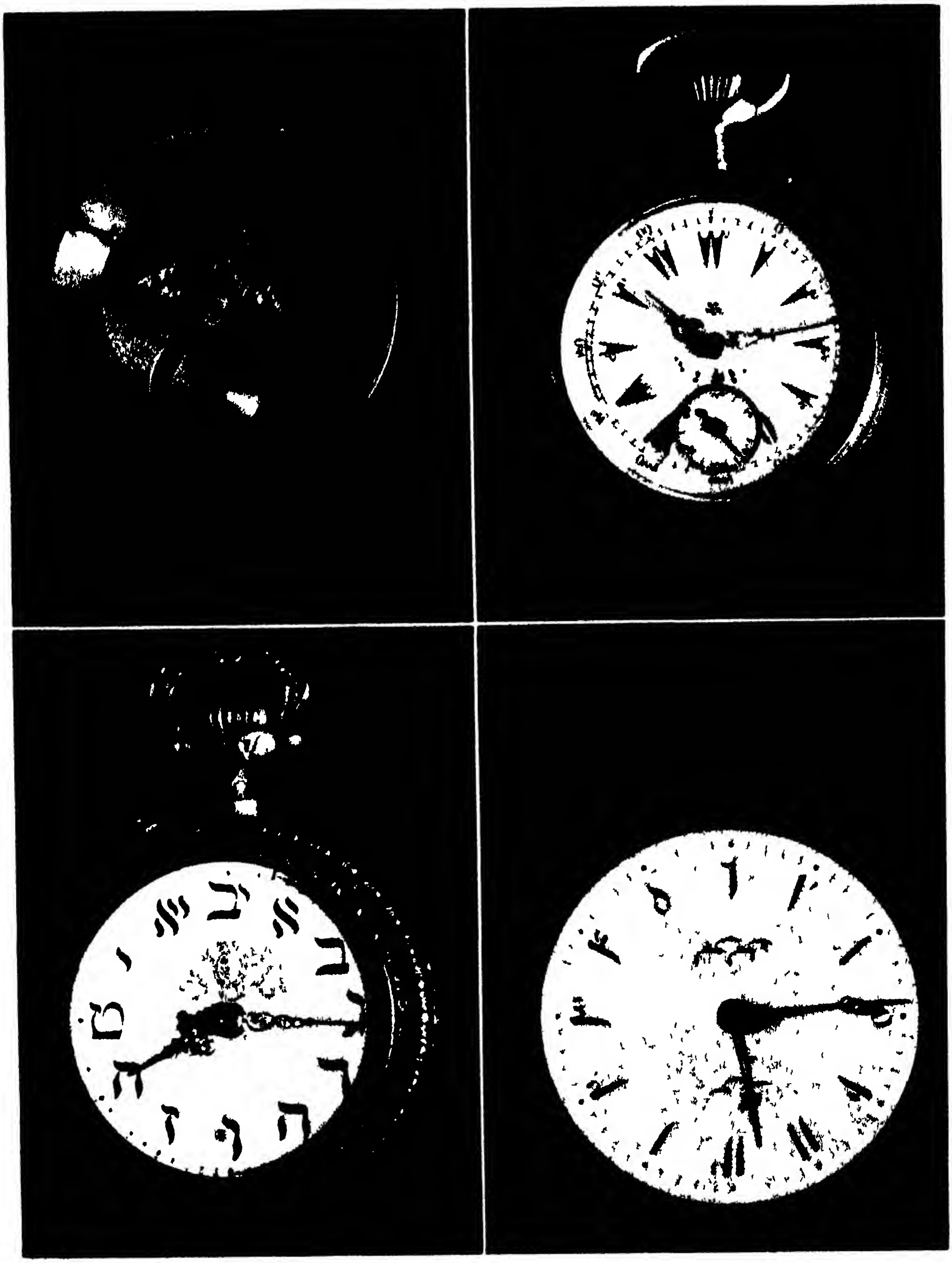


FIG. 1. WATCHES WITH ALPHABETIC NUMERALS IN DIFFERENT LANGUAGES
TOP LEFT GOTHIC OR OLD ENGLISH, RIGHT TURKISH, BOTTOM: LEFT HEBREW, RIGHT SYRIAN.

for many centuries and the style of clocks that had operated according to that system for three hundred years was discarded

In 1931 Turkey abandoned its old form of alphabet and numerals. On January 1 of that year the President, Mustafa Kemal, abolished throughout Turkey the use of the Arabic alphabet in whose characters for words and sentences as also for numbers Turkish literature and documents had been recorded and printed, and substituted the Roman characters for it

In 1792 the French revolutionists attempted to reform their calendar by dividing the months, weeks, days and hours decimally, which necessitated a change in the numbers on their timepieces This effort was only partially successful, after a precarious existence of only fourteen years the calendar of the revolution was abolished and the old one restored by Napoleon in 1806 Watches with dials numbered to conform to the calendar of the Republic were no longer of any use, their manufacture ceased, and few are now to be found An example is shown in Fig 12 (top, right)

To abolish at a single stroke the form of the alphabet, to alter the form, the names, the number of characters in which the literature and the records of a people are to be written or printed, to introduce into the schools new forms and to exclude the older ones that may have served for many generations, such a change can not but affect seriously a people's habits of living and even of thinking

Many centuries ago the Japanese adopted the Chinese system of time reckoning, in which the periods from sunrise to sunset and from sunset to the following sunrise were each divided into six equal parts or hours Thus their entire day from midnight to midnight or from noon to noon was twelve hours In 1605, the Dutch obtained official license from the Shogun to trade with the Japanese and began to cultivate commerce with them In doing this they brought to Japan their clocks with movement controlled by the foliot, and dial divided into twelve or twenty-four parts and numbered accordingly The Japanese succeeded in adapting this form of clock

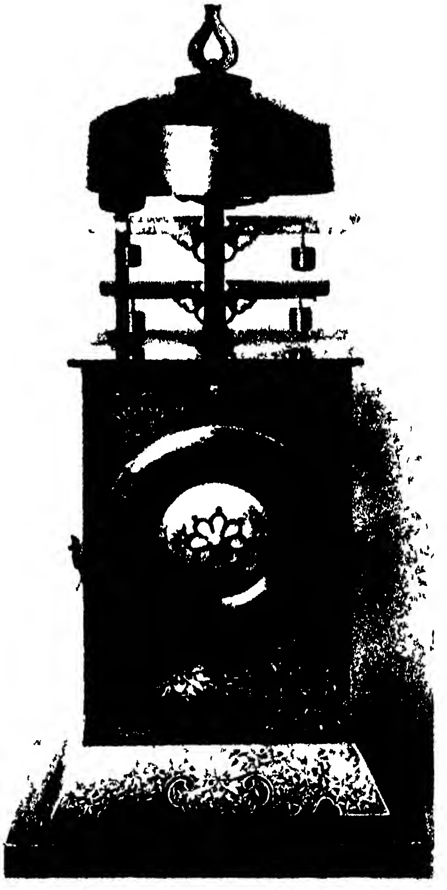


FIG 2 EARLY JAPANESE CLOCK WITH CIRCULAR DIAL

to their division of the day, but they numbered the hours in two sets of six each They employed only six numerals which they counted backwards, one, two and three were sacred numbers and must not be profaned by common use on clocks, so their dial numerals beginning, say, at midnight with 9 were 9, 8, 7, 6 (at sunrise), 5, 4, 9 (at noon); and repeating

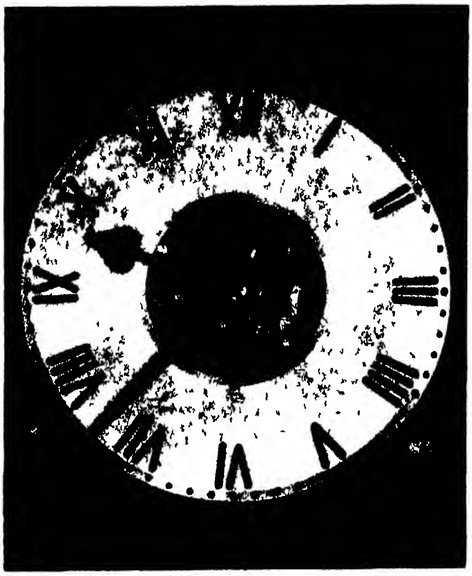


FIG 3 CLOCK DIAL WITH ROMAN NUMERALS RADIAL

the numbers in the same order to 9 again at midnight Circular dials were used on floor or shelf clocks and straight vertical dials for pillar or hang-up clocks Fig 2 shows one from the early seventeenth century, with circular dial

The hours were named as well as numbered, but while the same numerals were used for the six night hours as for the day hours, they were named differently, the entire set being

Name	Hour	Time
Rat	9	Midnight
Ox	8	
Tiger	7	
Hare	6	Sunrise
Dragon	5	
Snake	4	
Horse	9	Noon
Sheep	8	
Monkey	7	
Cock	6	Sunset
Dog	5	
Boar	4	
Rat	9	Midnight

The characters as well as the names for the symbols on the dial are Chinese In the illustration the inner circle gives the hours, the outer one the signs of the zodiac

Clocks of this kind are now, however, as unfamiliar to Japanese natives as they are to Americans

The characters on an engraved metal dial are cut out to a slight depth and the incision is filled with wax, which is usually black but may be of any desired color The late James Arthur, after experimenting with various designs, chose a thin, broad metal ring with a rather large open central circle This ring plate was marked with Roman numerals placed radially, and instead of being waxed or painted they were wholly cut out The ring was then secured upon a metal base plate that was uniformly dead black The effect was good An example of his own design and construction is shown in Fig 3 He described this clock as "having 12 inch dial of aluminum, the hour numerals being cut through These numerals are radial as shown by the inner ends being narrower than the outer, are less in height than one quarter the dial radius and members have semicircular ends This design makes them clean cut and distinct, leaving more clear space on the dial These heavy Gothic numerals ('chapters') with the spade hour hand and the plain minute pointer make a dial which can be read at a great distance and is my favorite design Compare this with the usual method of making the numerals one-third radius of dial and the hour hand long enough to entangle them" This mention of one third the radius as the "usual" length of the numeral is so casual as to give us to understand that it was a standard size generally approved and adopted It was followed more closely on early clocks than on those of to-day

Arabic numerals have been used in an erect or a radial position indifferently, Roman seldom erect, somehow, their rectilineal form seems to suggest naturally a radial position, they are rarely vertical, yet the erect position confers upon the face of the clock or the watch a

dignity that is lacking in the radial Fig 12 (bottom, left) is an example

The Wearer of a Watch Seldom Acquainted with Its Dial

As the numerals are ostensibly the clue to the hour, minute and second ticked off by the clock or the watch it would naturally be inferred that the user of it would be familiar with those on his own watch, but actually, in reading the time one gives little attention to the numerals —how little may be gathered from an amusing experiment When he has looked at his watch (perhaps for the hundredth time that day) and has put it out of sight, it is an old trick to ask him whether the numerals on the dial are Roman or Arabic He doesn't know Under the stimulus of a subconscious memory he hazards a guess and he may sometimes be right, but with the even chance of guessing right or wrong combined with the fact that his memory may be playing him false, he is more likely to be wrong and the laugh is on him, to his chagrin and the amusement of those around him Before he looks again at the watch if he is asked whether the numerals are erect in position or radial, he is in the same fog as before, pressed more particularly as to whether the figure for the hour six is right side up or inverted he is tempted to make a decision, only to find that his dial has no six, as it has been cut away by the circle for the seconds hand! Other changes may be rung on the same bell

Numerals are Sometimes Omitted

In view of such experiences figures on a dial would seem superfluous This is not so with a piece that is near enough to come directly under the eye of the observer, it is more nearly the case with one that is at a considerable distance or at a great height, as in a tall tower, and accordingly it is principally in monumental clocks that the numerals have been dispensed with Among notable examples are the clock on the City Hall in Philadelphia, installed in 1899, that of Colgate and Company in Jersey City, 1924, the famous clock on the Houses of Parliament, London, 1854–59, and that of the Siemens-Halske Electrical Works, Berlin, c 1925 These are too recent to be considered antique Latterly the popular desire for novelty has led clockmaking companies to use patterns that were formerly disapproved, and within the last few years they have produced many small electric clocks with no numerals on the

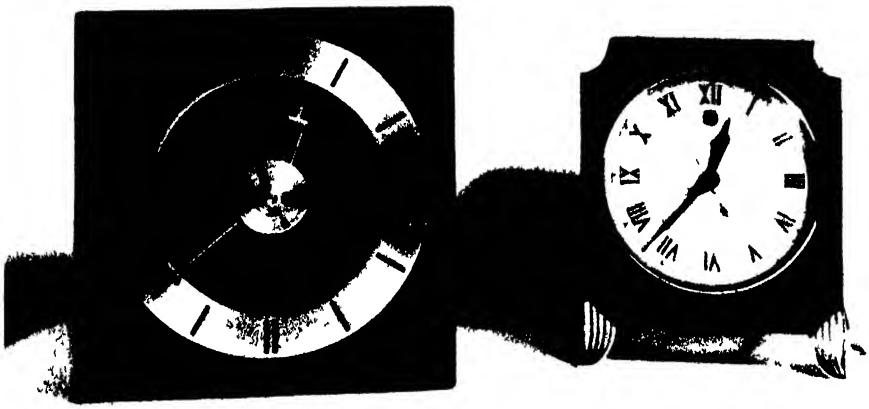


FIG 4 RECENT SMALL ELECTRIC CLOCKS
(*a*) WITHOUT NUMERALS, (*b*) IV FOR FOUR

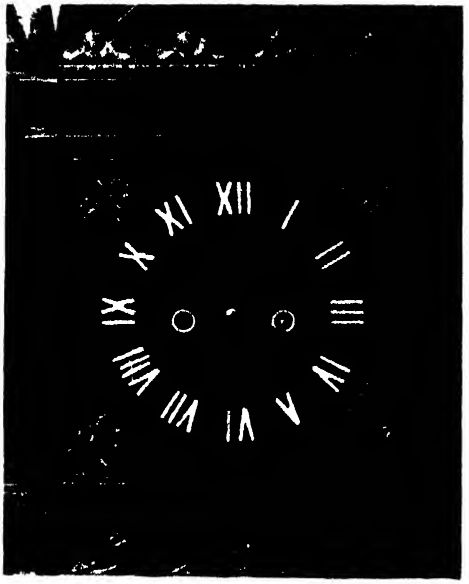


FIG 5 DIAL DISFIGURED BY RESTORER

dials In abandoning numerals the position of the hands was determined by lines, or a circle of dots, or perhaps (not to ignore ornament altogether), a ring of stars One is shown in Fig 4(*a*) If this is only a passing phase of fickle public taste, merely a fad, it doesn't matter for these clocks are not made for long continued service They are not costly and, like the dollar watch, when one gets out of order it is cheaper to get a new one than to have the other one repaired, and besides that, the oftener the style changes the better business for the manufacturer, clocks that have broken down can not be brought into service again as profitably as used cars

DISTINCTNESS THE FIRST ESSENTIAL

The function of the dial marking is to facilitate reading of the hour, minute, and sometimes second, so that the reader may catch it at a glance and he that runs may read To accomplish that the prime requisite is distinctness Any elaboration that interferes with this or with ease of reading is out of place, and to secure this ease and certainty size, shape and position of numerals are factors to be taken into account The earliest clocks had no dials at all, the hours were announced by strokes on a bell with hammers wielded by some person or by automatic manikins facetiously termed "Jacks"[1]

With the steady improvement in the time-keeping quality of clocks and watches the limitations of design grew more definite and more severe The earliest pieces were poor timekeepers Their users recognized that fact and because of it they felt free to lavish ornament upon their clocks, since it did not seriously impair their utility. In the seventeenth and eighteenth centuries this tendency was carried to extremes—hands were a complicated filagree and numerals as dubious as monograms But this was gradually changed and to-day the utilitarian character of the timepiece far exceeds the ornamental, so the hands and the numerals have been brought to the

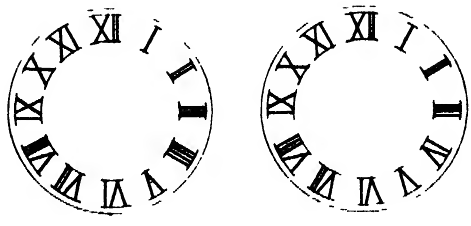
[1] The name originated in France about 1400 or soon after, although the earliest automata for the purpose were probably used on an Italian clock as early as 1351 Before that time clepsydras (water clocks) were the best timekeepers available For these a man was kept on duty to strike the hours by hand with a hammer, and this practice was followed sometimes with the earliest wheel clocks, but it was not long before figurines were constructed to do the striking automatically The earliest record in regard to this tells of a locksmith of Lisle named Jaquemart who was paid in 1422 for his services in connection with the celebrated clock of Dijon (1380), where the city authorities employed him to strike the hours Familiar allusions to his performance soon abbreviated his name to "Jaque" It hit the popular fancy so well that it was rapidly adopted throughout Europe for the automatic figure that took the place of the human one In the same familiar way he was called "Jack" in England, "Jean" in Flanders, "Hans" in German countries "The addition of quarters to the striking train," say the authors of "Le Monde des Automates," (Chapuis et Gelis), "led to an increase in the number of automatic strikers and soon Jaquemart was to be seen reenforced by his entire family his wife struck the half hour, his daughter the first quarter, and his son the third" Wood, in "Curiosities of Clocks and Watches," says the name was used in a con-

utmost plainness—a straight pointer for the minutes and a spade or spear head for the hours

In watches the most effective means to make the marking clear was the introduction of the enamel dial in 1635 to replace the previous metal dial On high-grade clocks and watches, especially those by French clockmakers, frequently the numerals were inscribed on porcelain or enamel plaques that were set in panels around the dial ring This began about 1700 and was popular during the eighteenth century, after which time the metal dial gradually gave way to the enamel and is seldom seen nowadays Fig 12 (center), however, shows a fine watch of French or Swiss manufacture, stem wind, late nineteenth century, in which the numerals are silver on small circles of blue enamel, set in a white enamel dial

Disfigurement Often Due to Restorer

When the making of clocks and watches was still a handicraft there were masters of designing as well as of constructing who produced cases of high artistic merit Then, as now, such beautiful work came often into contrast with other that was at best commonplace and sometimes was astonishingly ugly in design and of bungling workmanship This occurred most often when an incompetent workman undertook to repair a piece that was worn or had been injured It would be hard to find a more unpleasing dial than that of Fig 12 (bottom, right) The watch is French or Swiss, dating from



(a) (b)

FIG 6 DIALS WITH BALANCED AND UNBALANCED NUMERALS

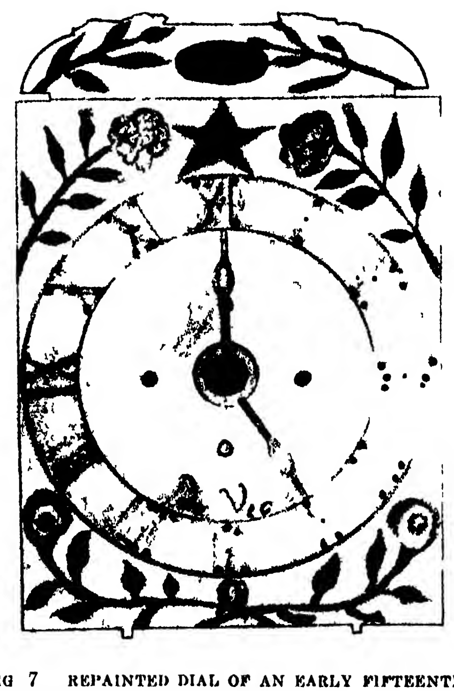
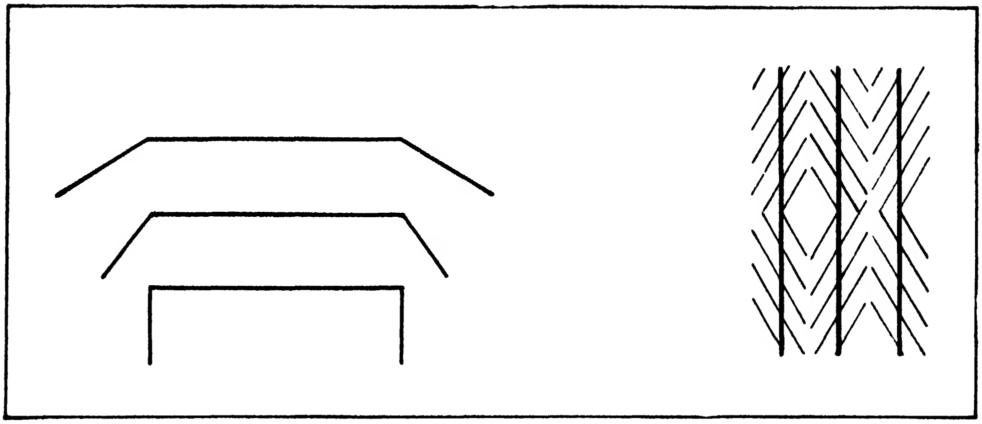


FIG 7 REPAINTED DIAL OF AN EARLY FIFTEENTH CENTURY CLOCK.

temptuous way, but that must have been only in England His citations are all from English writers, on the Continent the tone was one of pleasant indulgence These Jacks were always humorous, good natured fellows Their lively expression seemed to be a reaction against the somber mood of the Middle Ages with its miracle plays and monastic asceticism, and a relief from the mottoes that enshrouded in a monotone of gloom the face of sun dials in common use at that time The spirit of the age that was growing more luminous began to ferment in the bourgeoisie before it showed itself in Royalty or in court circles Nor was the Renaissance limited to literature and the fine arts *vultus est index animi*, and the Jacks were the instrumentality by which the face of the clock expressed the rebirth of cheerfulness in humanity No plainer parallel between the animate and the inanimate can be found than between humanity and timepieces When "Hickory, dickory dock" originated is not known, but its connection of mice and men is an everlasting allegory of the sympathetic relation between man and the clock Peter Bells are numerous, to many people a clock is just another clock—another "primrose by the river's brim"—yet it has always been the announcer of occasions joyful or solemn, and a companion of lonely hours



(a) (b)

FIG 8 OPTICAL ILLUSIONS DUE TO POSITION OF LINES

about 1750 The maker is unknown, and it was probably fortunate for his reputation that he did not inscribe his name

FIG 9 DUTCH HOOD CLOCK, ABOUT 1690

upon his work, but it is to his credit that he should have perpetrated such a monstrosity anonymously rather than imitate the work of some well-known artist

Originals suffered most at the hands of repairers Fig 5 shows the upper part of a case that encloses a clock by Nicholas Massy, a French Huguenot clockmaker of good standing, who migrated from Blois to London *c* 1680 The clock is of a high order of workmanship The case, of wood, is ecclesiastic in design and may be of the same date as the movement—*i e*, 1680–1690, but is probably somewhat later The present dial board shown in the figure is a good illustration of the clumsy treatment we have mentioned It is especially noticeable in the numerals The original may possibly have been marked with IV for four, but there is no excuse for placing V (five) as here shown

Why IIII Instead of IV for Four?

A feature in the dial marking that has often aroused comment is the use of IIII instead of IV for four The latter is undoubtedly the proper form in Roman notation, but the former is so general on clock and watch dials that IV looks odd Two explanations of this singular alteration of the numeral are current the first, a story ingenious and apt enough to be

plausible though probably only a story, and the second, an attempt at a rational explanation on the ground of good taste. We give both.

(1) When Henri de Vic had about completed his famous clock for the Royal palace of King Charles V at Paris, 1370, he submitted to His Majesty a design of the dial for his approval. It was marked with IV. The king objected to that, preferred IIII, de Vic defended IV as the correct Roman form for four. The king testily replied that that made no difference, he would not have it, was he not "Charles the Wise"? Who was to gainsay him? So IIII it became, and IIII it has been ever since.

(2) Many early clockmakers as well as later ones possessed both inventive talent and artistic sense. They were not slow to perceive that the ring of numerals with IIII presented a better *balance* than one with IV—so much better as to win general sustained preference.

Fig. 6 shows the two side by side. The letters used are I, V and X. In the popular dial, Fig. 6(*a*), I dominates in the first four numbers, V in the next four and X in the remaining four. In (*b*), I is most prominent in only three numerals, V in the next five and X in the remaining four, the numbering is not symmetrical, and (*a*) has proved more generally acceptable. It is interesting to note, however, that in the multiplicity of clocks now produced daily there is the utmost variety in design of dials, including a reversion to forms once rejected. Fig. 4(*b*) shows one recently adopted by the General Electric Company for some of their small domestic clocks, with IV for four. While IV is very unusual on small dials, it was by no means so uncommon on tower clocks. The comprehensive treatise "Les Horologes Astronomiques et Monumentales," by Albert Ungerer (Strasbourg), shows numerous examples.

The clock of which the dial is shown in Fig. 7 is remarkable in many ways. The coloring and marking are dim from age, but after cleaning a correct copy was drawn and freshly colored and the illustration is from this copy. The black dots which are here made heavy for emphasis are faint on the original, but they are quite distinct and their meaning is plain. When an early restorer (more of a bungler than an artist) undertook to repaint and improve the appearance of the clock face which had become faded he had first to remove all traces of the original and was obliged to mark the position of the numerals. This he did by indenting the plate with a round-end punch. The indentations would not show when again painted over. Apart from the name "de Vic" inscribed on the dial, which it would be difficult to substantiate, there is good evidence that the clock dates from very early in the fifteenth century, and the dial is numbered in a way to indicate that de Vic's contemporaries or immediate successors were by no means unanimous in accepting the dictum of

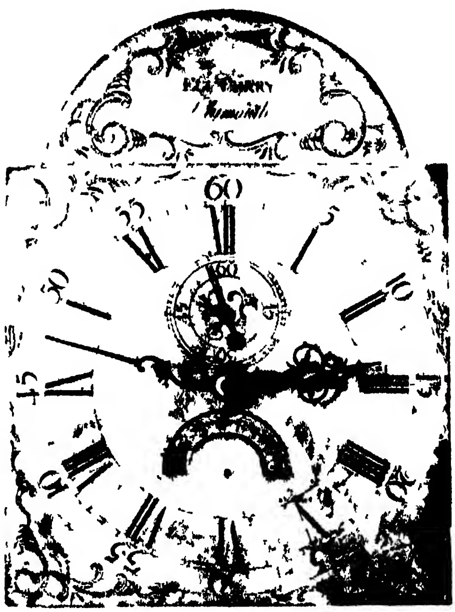


FIG. 10. DIAL BY DANIEL BURNAP FOR EARLY ELI TERRY CLOCK CORRECTED FOR PARALLELISM

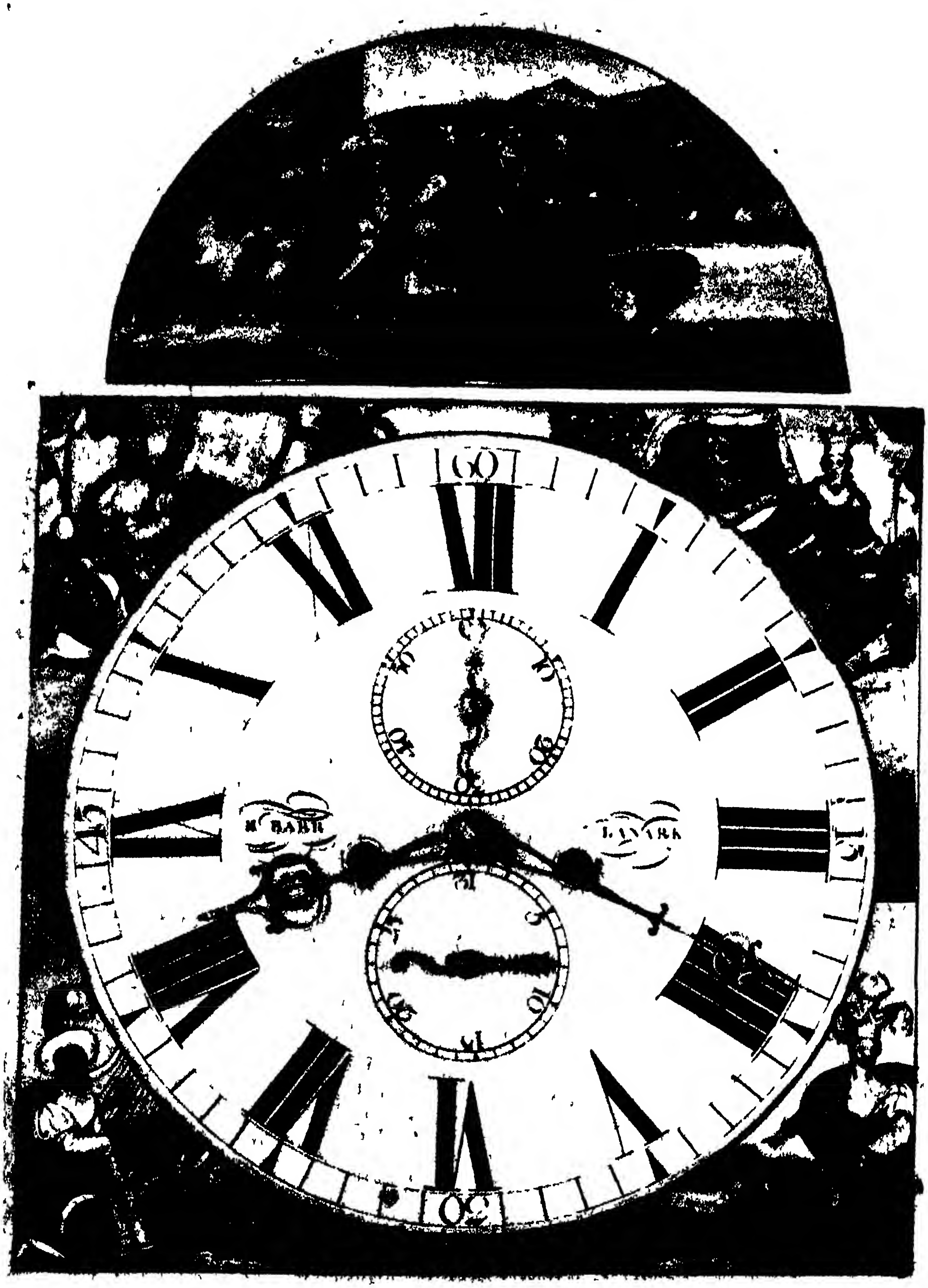


FIG 11 DIAL OF SCOTTISH CLOCK, ABOUT 1700
NOT CORRECTED FOR PARALLELISM.

King Charles V in respect to the numeral four.

The clock as it stands, a rare example of serendipity, is a mine of information; seldom does a single antique specimen tell so much of a story or tell its story so clearly. The sturdy monitor of the passing hours had kept faithfully at his job for generations after his maker had passed away, but from time to time he showed that the years were taking toll of him, pivots wore small and had to be repolished, and holes wore large and had to be bushed, painting became dingy and had to be freshened; but the stout iron mechanism needed no renewal, and to-day the clock ticks on just as it did five hundred years ago In repainting the dial as described above the artist(?) had in mind the clock as it had by that time grown to be, four was always IIII, so far as he knew, and so he painted it here, although the dots show unmistakably that the original was ΛI So, too, absurdly he painted two hands upon the dial, although the old servant had always done his best with only one Why any hand should have been painted on the dial is a mystery, since the hand is no part of the dial and is never attached to it

Optical Illusions

In one especial respect a dial with Roman numerals is deceptive The eye does not see it as it really is, even when it is plainly in view, its appearance is an optical illusion Among familiar peculiarities of vision that include such illusions the most common are those that come from the position of simple lines, straight or curved Relative position is responsible for apparent distortions or misconceptions How often does one, in looking at himself in a plane mirror, realize that the right eye in his face is the left eye in the image, and that all the features are similarly perverted? Something more than a mere say-so—nothing less than actual measurement with ruler and scale—is needed to convince an observer that the three horizontal lines in Fig 8(a) are of the same length, or that the heavy vertical lines in (b) are straight and parallel

A similar illusion appears oftentimes on a clock dial When we spoke of the position of the lines as erect or radial, by radial we meant directed in the main toward the center but not necessarily directly toward the central point although sometimes, if the numerals are short, the latter plan is adopted as in Fig 3 The marking is intended to give the effect either of parallelism or of actually converging upon the center, *i e*, actually radial, generally the lines are meant to look parallel When they do so the apparent parallelism is itself an illusion If a rectangular outline stands upon a small circle and is circumscribed by another circle that is necessarily larger the figure will look larger at the base than at the top It is most plain with the the four I's To look just as wide at the top as at the foot the group of lines must actually be somewhat narrower at the foot, those containing X as well as those with the II, III and IIII This fact was realized by early dial-makers, some of whom shaped their numerals to accord with it When an unskilled "restorer" attempts to repaint or replace an early dial he is apt to overlook this detail—most probably is unaware of it In some instances the designers over-corrected the fault This seems to be the case in the IIII, VIII and XII on the Dutch hood clock, Fig 9, where the members of the numerals are evidently convergent though not so much so as to meet at the center, but it is a question whether the tapering of the groups here was not intentional, the designer anticipating the preference expressed by Mr Arthur in connection with Fig 3 but not carrying it so far

American dial-makers were not as careful to observe this correction as the Euro-

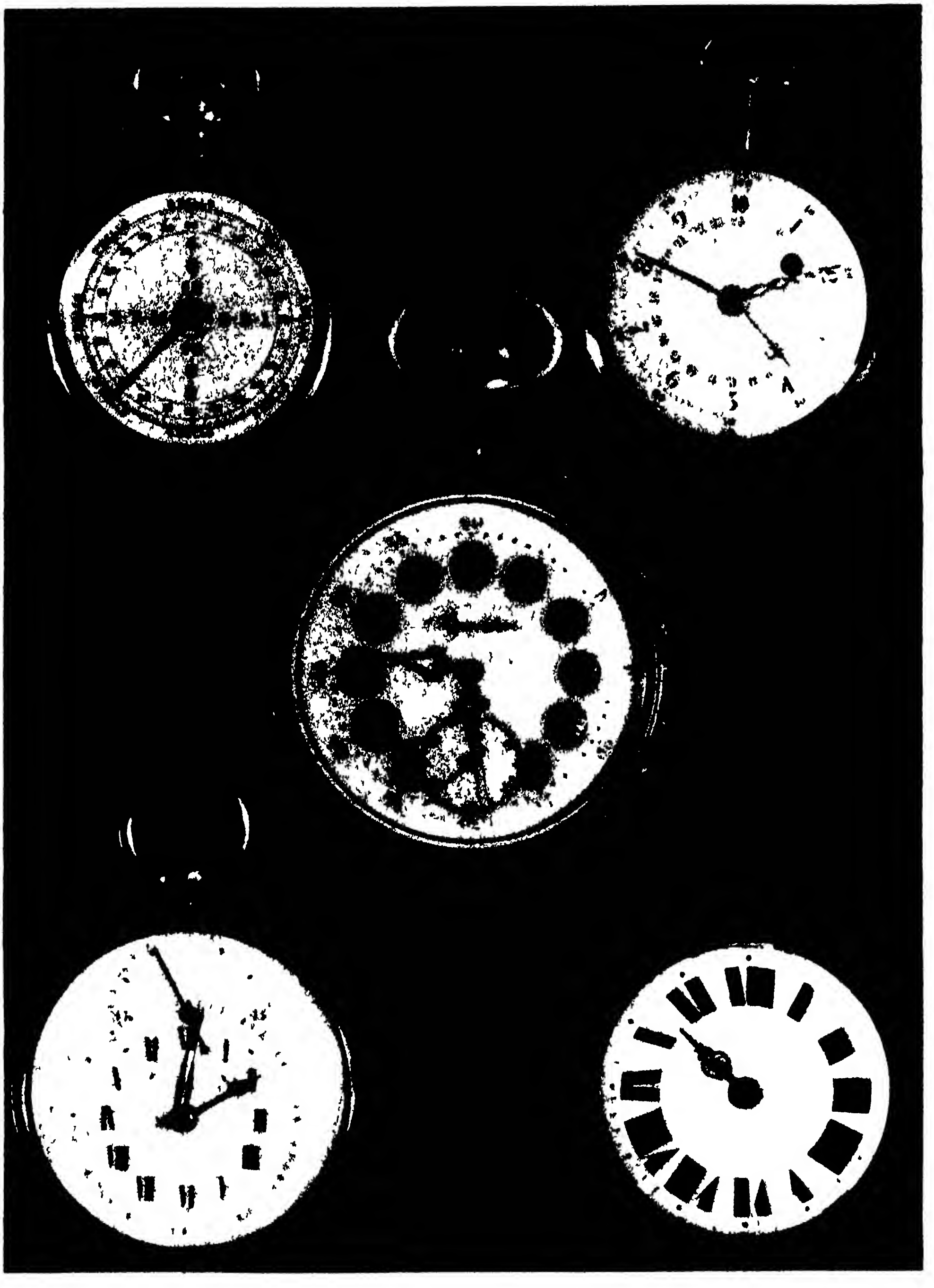


FIG. 12 WATCHES WITH NUMERALS VARIOUSLY PLACED

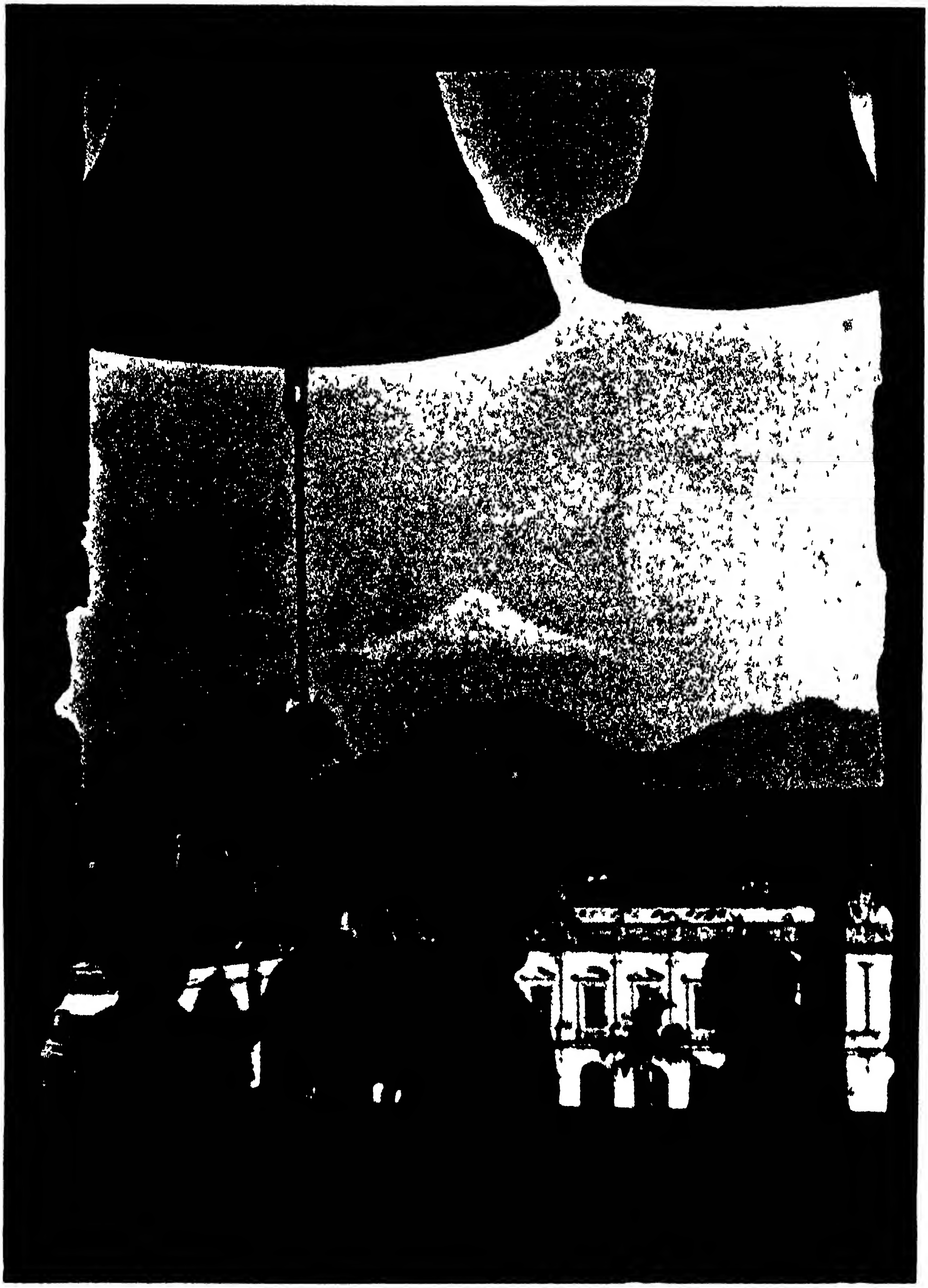
TOP LEFT, MARINE WATCH, MODERN RIGHT, WATCH OF FRENCH REPUBLIC, C 1796 CENTER NUMERALS ON ENAMEL PLAQUES, MODERN BUT IN XVIII CENTURY STYLE BOTTOM LEFT, ROMAN NUMERALS ERECT, 1798 RIGHT, NUMERALS IN BAD TASTE, C 1750

pean Daniel Burnap, one of the best American early clockmakers, heeded this correction both in clocks of his own construction and in dials which he engraved for early long-case clocks made by Eli Terry In the Scottish dial shown in Fig 11 the spacing and widths are equal, the members are parallel, and the resulting distortion, especially in the IIII, is plain It is about the only defect in this beautifully conceived and skilfully executed piece of work Comparing Figs 10 and 11, in the former the members of the numerals are actually convergent inward but are apparently parallel, in the latter they are parallel but apparently divergent inward

With Arabic numerals the conditions are different, except in the 11, and there it is of little consequence

Cescinsky and Webster, in "English Domestic Clocks," give illustration covering the period from 1618 to 1850, of more than two hundred and fifty clocks, large and small, with Roman numerals, which all used IIII, none IV, about one in ten corrected for parallelism, in many the wider foot of the numeral was so plainly apparent that correction would have been an improvement In just one, dated 1790-1795, the I's were radial, as in the James Arthur dial, Fig 3

Fig 12 shows a group of watches with numerals variously placed On the ship's watch (top, left), the outer circle indicates the "bells" by which the duties of the crew are regulated, one bell for every half hour, there is also a circle of minutes, by tens, and the heavy figures in the horizontal and vertical rows give the hours in succession when the single hand crosses them At the top, right, is the watch introduced by the French Republic in 1792, with day and hour divided decimally, as already described, the numerals on the watches in the (center), (bottom, left), and (bottom, right), also have been explained in preceding text



Photograph by Herbert C Lanks.

RINGING THE ANGELUS CHIMES AT TWILIGHT

FAR IN THE BACKGROUND RISES MAJESTIC MOUNT ORIZABA

THE PAN AMERICAN HIGHWAY

By HERBERT C LANKS
MEXICO CITY, MEXICO

"How soon will I be able to drive my car through Central America to the Panama Canal?" is frequently being asked to-day Ten thousand American tourists a year travel the completed section of the Pan American Highway to Mexico City, through a land of wonders which offers as many strange sights as any European country Below Mexico lies Guatemala, latest land of marvels discovered by the tourist Once arrived there, one can motor over highways to almost any place of interest in the country, viewing remains of buried civilizations and the most colorful indigenous people of to-day on this continent Next on the route southward comes little Salvador, teeming with a population of advanced Latin American culture and with a motor road extending its entire length Nicaragua, country of lakes, cannot be crossed yet by motor, but the highway is being pushed daily northward and southward from Managua, its capital Each year many tourists visit Costa Rica, with excellent highways to many points of interest, including active volcanos, a fine concrete road leading to the brink of one Farthest south lies Panama with its canal The night life, the history of the days of the Spanish Main, the pleasure resorts make this country a tourist Mecca rivaling countries of equal size in Europe One can travel nearly the full length of the country by motor road What a stream of travel will head southward when these existing stretches of highway are all connected, making an unbroken highway of three thousand miles from the American border, through seven foreign countries, to the Panama Canal! What does the motorist experience now in motoring through these countries? What will he be able to experience when the certain stretches of highway, now under construction, will be completed? Let us motor over this Pan American Highway as much as it is possible at present and cover the intervening parts with other means of transportation, as the author of this article did

MEXICO

We cross the international frontier between the United States and Mexico at Laredo, Texas Here we display a Mexican tourist permit, which we may secure here, if we have not already secured it from the Mexican consul in our nearest city, for one dollar We also bond our automobile at an expense of about a dollar We are permitted liberal allowances of personal effects in crossing the border, and in about fifteen minutes we have cleared through everything, thanks to very courteous Mexican customs and immigration officials

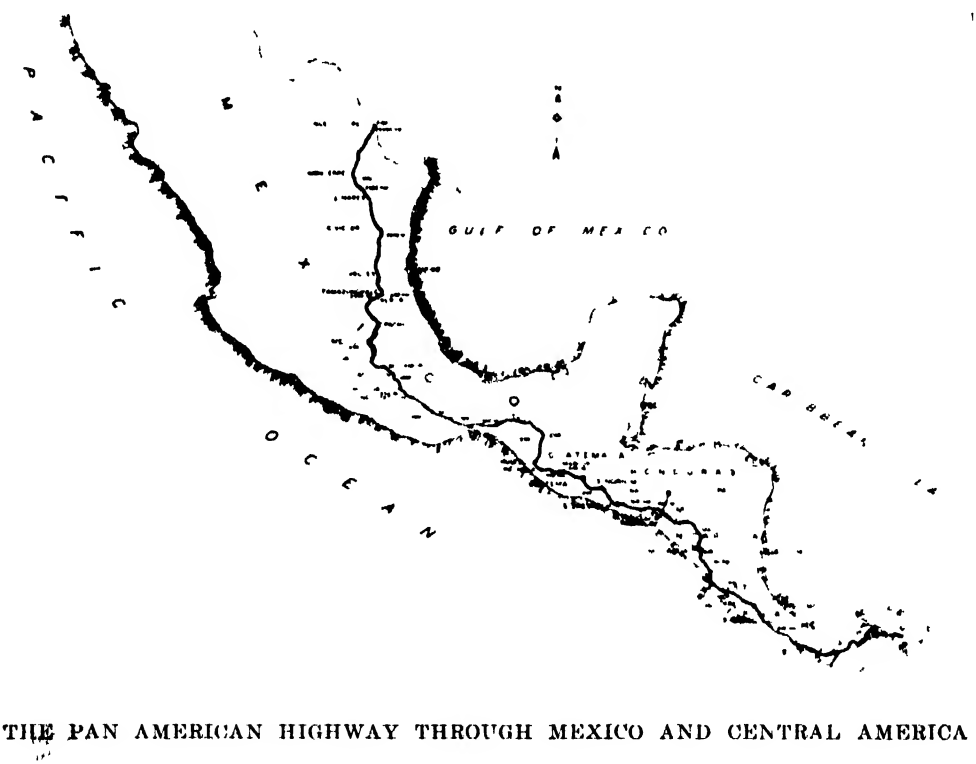
We are now in Nuevo Laredo, Mexico, a small border place which, although quite different from our own towns, is yet not quite real Mexico It is the hybrid border town, as may be expected, catering with its night clubs and cabarets to Americans who wish to enjoy something a little different from their own country across the border Although Spanish is the language spoken, a great deal of English is heard so that one can get around comfortably In fact, one can travel all along the Pan American Highway to Mexico City without being able to speak Spanish

From the Mexican border town of Nuevo Laredo, it is 150 miles south to

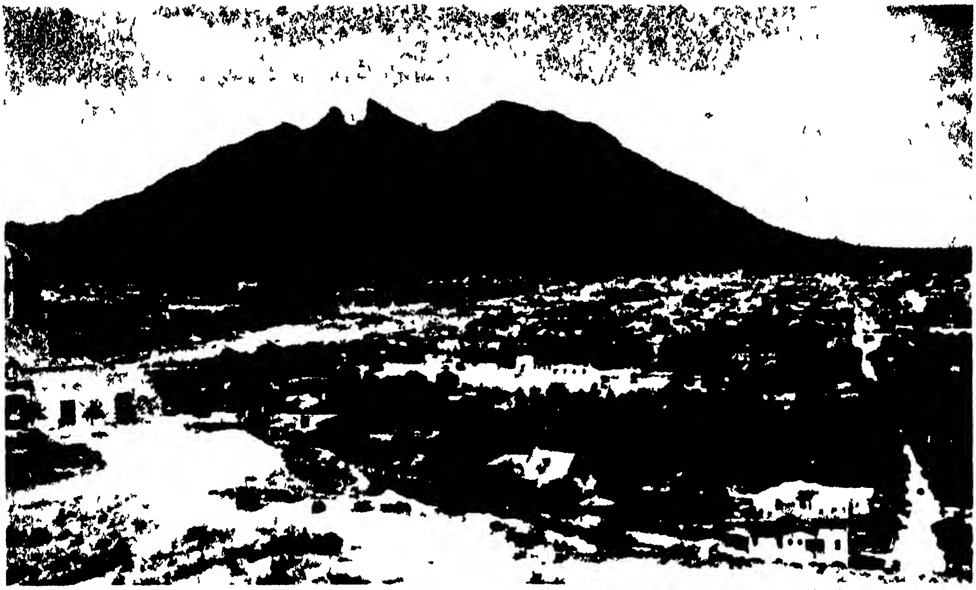
Monterrey through country that is rather desert-like. Parts of this stretch are monotonously level and straight; it boasts of having the longest continuous piece of straight highway in the world. Other than an occasional cowboy and a goat-herd with his flock, not much else of human life is encountered save when one dashes through a sleepy Mexican village along the way. One does not stop at many of these places save for gasoline and an ice-cold bottle of refreshment as relief from the intense dry heat of northern Mexico.

At last, mountains begin to loom up in the distance. They become larger and larger as we approach them, until we are at their foot and begin the ascent to cross through the long Mamaulique Pass. Although there is a steady climb for some miles, the broad easy curves of the highway and differences in scenery offer a welcome relief to the monotonously straight road and the hot desert country we have just come over. We glide down into the fair-sized village of Sabinas Hidalgo, where we might comfortably remain for the night, but modern Monterrey beckons us onward.

Monterrey is a city of a third of a million inhabitants. Although typically Mexican, it has been in such close contact with American tourists so many years that it offers every accommodation that any modern American city can offer. Its night-life, although not that of Paris or New York City, is glamorous and interesting. It has many movies with late-run American films. It offers all kinds of sports, including the bull fight. It has its places of historical and cultural interest. Monterrey is also a busy industrial city in parts, with large modern breweries, cement factories and iron foundries. It makes and has for sale artistic products of Mexican handwork not encountered in the United States. Out of Monterrey, there are beautiful scenic drives



THE PAN AMERICAN HIGHWAY THROUGH MEXICO AND CENTRAL AMERICA



Photograph by Herbert C Lanks

PANORAMA VIEW OF MONTERREY

THIS FIRST STOP ON THE PAN AMERICAN HIGHWAY IN MEXICO IS 150 MILES SOUTH OF THE BORDER "SADDLE BACK MOUNTAIN" IS IN THE BACKGROUND

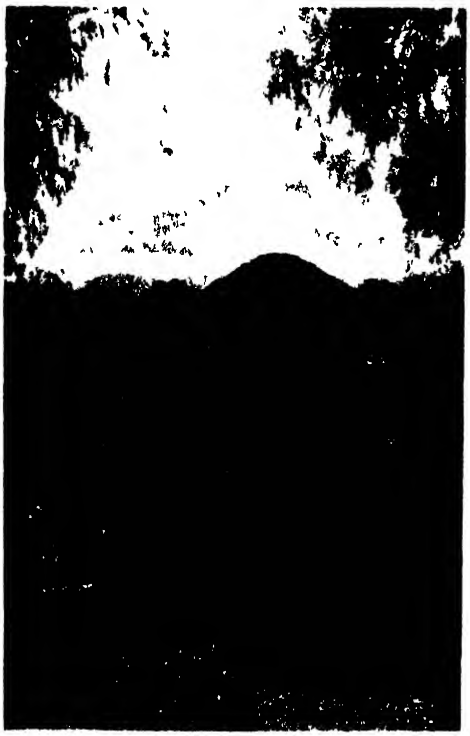
Photograph by Herbert C Lanks

THE PAN AMERICAN HIGHWAY NEAR TAMAZUNCHALE

PASSING UNDER THE SHADE OF A FLAMBOYÁN TREE WHICH IS A RIOT OF RED FLORESCENCE IN THE SPRING OF THE YEAR

Photograph by Herbert C Lanks

A MEXICAN PEON BOY RESTS WITH HIS BURROS



Photograph by Herbert C Lanks

TEMPLE OF THE SUN—TEOTIHUACAN

ABOUT THIRTY FIVE MILES NORTHEAST OF MEXICO CITY IS THE ARCHEOLOGICAL ZONE OF TEOTIHUACAN, WHICH COMPRISES AMONG OTHER RUINS THE GREAT PYRAMID OF THE SUN IT IS 216 FEET HIGH AND COVERS MORE AREA ON THE BASE THAN THE LARGEST OF THE EGYPTIAN PYRAMIDS

which make it quite worth while tarrying here for days The climate of Monterrey, which lies at an altitude of 2,000 feet, is delightful, warm, but not oppressively hot

The distance from Monterrey to Mexico City is about 500 miles and is usually done in two stages with an overnight stop halfway There is a great variety of scenery along this five hundred miles, some of it rivalling any in the world The first half of the distance to Tamazunchale or Valles is mostly low country, somewhat desert-like, but turning more and more to the lush, humid tropics of riotous vegetation as one proceeds southward At Tamazunchale, the highway begins to climb the high Sierra Madre mountains to the high central plateau of Central Mexico, which is cool and has an entirely different climate and vegetation It is in the center of the high central plateau, at an elevation of a mile and a half above sea level, that Mexico City is located

Immediately south of Monterrey we enter the rich fruit sections in the valley around Montemorelos, where great orchards of oranges and citrus fruits stretch along the highway The largest place south of Monterrey is Victoria, the capital of the state of Tamaulipas, a typical Mexican provincial capital If one had Mexican friends in such a vicinity as this a whole new world of experience would be opened, for the Mexican has his way of enjoying life as do we Americans in our own communities

We cross the Tropic of Cancer, marked by a monument on the side of the road, south of Victoria At places the highway climbs to high mesa or plateau, from the summit of which we can see tremendous areas of pasture lands on all sides, for cattle-raising is the important industry along most of the highway Only a small proportion of the total area of Mexico is cultivated. As we approach Villa Juarez, we note the land is irrigated and more intensely cultivated We are now not far

inland from the Gulf of Mexico. The rich black earth is more frequently watered with life-giving rains during the rainy season, but during the dry season, that is, from October to May, there is scarcely any rain at all, hence the need for irrigation. This area around Villa Juarez is especially given to the cultivation of sugar cane

South of Villa Juarez, the highway passes through great areas of nothing but palm forests Wild parrots and love birds are seen in great numbers with many other species of tropical birds, including, at times, the brilliantly colored macaw and the loud chacalaca, or jungle hen Natives offer for sale captive armadillos, peccaries, coaties, deer, ocelots

Photograph by Herbert C Lanks

A YOUNG MOTHER IN MEXICO

CALMLY NURSES HER OFFSPRING WHILE AWAITING THE TRAIN AT THE STATION

Photograph by Herbert C Lanks

A PEON GATHERER OF MAGUEY SAP

FROM WHICH THE NATIONAL DRINK PULQUE IS MADE THE APPARATUS HE CARRIES ON HIS BACK IS A GOURD DEVICE USED FOR EXTRACTING THE SAP FROM THE HOLLOW CENTER OF THE MAGUEY PLANT THE POINT IS PUSHED INTO THE HEART WHERE THE SAP HAS ACCUMULATED OVER NIGHT AND THE AIR EXHAUSTED FROM A HOLE IN THE TOP BY SUCTION THE SAP RUNS UP INTO THE GOURD AND IS THEN EMPTIED INTO A CONTAINER ON A DONKEY'S BACK

Clouds of butterflies of many species and hues are seen along the road at certain times of the year Strange wild flowers of many species and colors are seen that are new to the tourist Entirely different types of trees are encountered, many of them of economic importance in the native life It is a new world to the American tourists, this tropical Mexico

Both Valles and Tamazunchale are rivals for the half-way stopping point between Monterrey and Mexico City

Photograph by Herbert C Lanks

A MEXICAN GIRL MAKING TORTILLAS

TORTILLAS ARE MADE OF SOAKED CORN, GROUND INTO A DOUGHY MASS ON TOP OF THE STONE METATE, SLAPPED INTO A THIN CAKE AND BAKED ON TOP OF A CLAY SLAB

Both have fine accommodations for the overnight stops Neither offers much of interest to the transient, but both offer much to the student For one who wishes to tarry a while to study the natives or natural life, Tamazunchale offers the greatest variety, for it is right at the foot of the mighty Sierra Madre Mountains, in which each several hundred feet of ascent offers a change of flora and fauna Both Valles and Tamazunchale are in the hottest and most sultry of tropical sections encountered enroute At Tamazunchale, the highway leaves the low, hot, tropical lands and starts the long upward climb to the cool plateau of central Mexico at eight thousand feet elevation

The ascent from Tamazunchale up the tremendous Sierra Madre mountain range is one of the most spectacular and scenic stretches of highway in the world Although never over a 7 per cent grade, it is so continuous, and the curves around the mountain folds are so numerous, succeeding each other in such dizzy repetition, that one experiences thrills approaching that of a roller coaster In addition, the highway is often carved out of the sheer face of a mountain side which drops down in many places, several thousand feet Many times, with the nose of the car pointed up grade and swinging around a sharp curve on the incline, one gets the sensation of being about to dash off into space Words can not describe the awesomeness of the spectacle For hours, one sensation succeeds another One leans back to catch his breath after one dizzy breath-taking spectacle only to be plunged immediately into a panorama of even greater breath-taking stupendousness Hour after hour, one tremendous panorama succeeds another, until we are left weak with so much in such rapid succession When, after hours of this sensational grueling sightseeing, we reach the

more level stretches of the plateau, we view with relief the tranquil fields of corn and maguey However, much of this high plateau is desert-like, for again we are in the region of a prolonged dry season

Even the native people change as does the scenery, climate and vegetation Mexico is a country of many different unabsorbed native Indian races Down in Tamazunchale, we met the Huastecan type, closely related to his Aztec cousin higher up in the mountains and on the plateau Around the Tula River valley, and especially around Zimapán and Ixmiquilpan a hundred miles or more outside of Mexico City, we encounter a different Indian type again, the Otomi They first attract our attention as we see the women folk hurrying along the highway, engaged in a peculiar practise of spinning maguey fiber as they walk along They have a bunch of the coarse white fiber on their shoulder or arm, and by means of a crude spinning disk of clay on a peg, they dexterously draw out the fiber and spin it into a continuous thread which accumulates as they walk along So little compensation do they receive for this work that they must spend all their waking hours working at it to earn enough for their meager subsistence level of living Even children must participate in the endless toil

As we approach Mexico City, it is like nearing a port on an ocean, for traffic gets heavier and heavier Yet, like the ocean, we see, for the most part, nothing but wild wastes Metropolitan Mexico City, with its densely surrounding populated sections, is not yet visible The capital, with its periphery of numerous communities, occupies the great circular valley bowl of Anahuac, fifty miles in diameter and surrounded by mountains on all sides Outside of this hidden green Eden is nothing but arid plateau for seemingly interminable distances The high-

Photograph by Herbert C Lanks

INDIAN WOMEN IN A MEXICAN MARKET PLACE

Photograph by Herbert C. Lanks

MOCTEZUMA RIVER, LOOKING FROM THE PAN AMERICAN HIGHWAY

FROM ABOVE IT APPEARS LIKE A RIVULET IN THE DEPTHS BELOW

Photograph by Herbert C. Lanks

MEXICAN WOMEN WASHING—TEOTIHUACAN

A SCENE SHOWING THE CACTUS LIKE FLORA OF THE "MESA CENTRAL" OF CENTRAL MEXICO HERE WATER IS SCARCE AND USE IS MADE OF EVERY AVAILABLE SUPPLY, SUCH AS THAT COLLECTED IN THE POOL SHOWN. THE INDIANS ARE OF THE NAHUATL GROUP

est point on the whole international route (8,000 feet) is reached just before descending into the Mexican valley from the north On the other three sides even higher peaks inclose the valley, but there are somewhat lower passes through them To the southeast the perpetually snow-capped peaks of Popocatepetl and Ixtaccihuatl tower majestically over the landscapes From time immemorial, probably a millennium before the coming of the white man, this Anahuac valley has been the seat of great civilizations At any rate, various remains of unknown people exist to-day throughout this valley, many in a fine state of preservation

There is greater evidence that we are approaching a metropolitan area now Towns are more frequent, land becomes more intensely cultivated and traffic becomes heavier Before we know it, we are on the outskirts of Mexico City. A guard stops us at the edge of the city and offers to direct us, ascertaining where we are going, offering us a guide and chauffeur It is very wise for the American tourist to engage one of the latter at a few dollars a day, for the narrow streets and unfamiliar sights and unusually heavy traffic of this great metropolis are very bewildering In case of need it is often difficult to find any one who speaks Spanish, these paid guides speak both English and Spanish

Mexico City has been referred to as "The City of Palaces," "The Paris of North America" and many other complimentary titles There is ample reason for such designations It is called "City of Palaces" because throughout the city there remain the great houses, or palaces, maintained at one time by wealthy land-

Photograph by Herbert C Lanks

FLOATING GARDENS OF XOCHIMILCO

ONE OF THE OUTSTANDING PLACES OF INTEREST JUST SOUTH OF MEXICO CITY IN PRE CONQUEST TIMES THE ENTIRE AQUATIC CITY WAS SURROUNDED BY WATER ON WHICH FLOATED MAN MADE ISLANDS OR RAFTS COVERED WITH EARTH THE REMAINING ISLANDS HAVE BECOME ATTACHED TO THE BOTTOM AND NO LONGER FLOAT THEY FORM A LABYRINTH OF CANALS LIKE MODERN VENICE AND A ROMANTIC PLACE TO VISIT ESPECIALLY ON HOLIDAYS WHEN THEY ARE TEEMING WITH BOATS

Photograph by Herbert C Lanks

EARLY AQUEDUCT AND WATER TOWER AT LOS REMEDIOS

THESE PICTURESQUE REMAINS OUTSIDE OF THE CAPITAL ATTRACT MANY TOURISTS

owners who lived in feudal splendor Mexico City is like Paris in many respects, the shops, the stores, the plan of the city and the general atmosphere But Mexico City has much more This, however, takes time to discover A striking fact is that it consists of parts reared in the conquerors' times, by Cortez and his followers, and also contains the ultra-modern type of building with all the intermediate stages

From Mexico City, highways, railways and trolleys radiate in all directions to various points of interest To the north of the city is the wonderful archeological zone of Teotihuacan In fact, there are fine archeological sites of some kind in nearly every direction from the city, including pyramids, temples and the burial grounds of the many civilizations that inhabited this great Anahuac valley of Mexico One pyramid, Tenayuca, like Ancient Troy, has seven layers of superimposed construction The scores of beautiful churches and old convents rival each other in attraction Then, there are the Floating Gardens of Xochimilco, Venice of Mexico There are museums and institutions of every kind, some of them old when our forefathers stepped ashore at Jamestown and Plymouth There are natural wonders like the caves of Cacahuamilpa, large enough in which to place one of our modern skyscrapers There are vistas and scenic sights outside of Mexico City to furnish interesting trips for days and weeks, Amecameca at the foot of snow-capped Popocatepetl, the tremendous panoramic sights on the drive to old Cuernavaca, or artistic Taxco, the baths of Cuautla, the drive through the Mexican Alps from Pachua to El Chico There are the people and their works of to-day, in many cases pursuing their crafts as of centuries ago hand-worked jewelry, leather, basketry, ceramics and textiles There are the quaint dances and customs of colonial

and even more primitive days In short, Mexico and especially the central part, within driving distance of the capital, offers an endless variety of strange sights and new experiences, a new world of to-day, to-morrow and yesterday, all in one

It is now practical to drive south of Mexico on the Pan American Highway route as far as Tehuacan, one hundred and fifty miles over paved road Here are located the famous baths of Garci Crespo Throughout a considerable part of this route southward the three perpetually snow-capped peaks of Popocatepetl, Ixtaccihuatl and mighty Orizaba are visible Sixty miles southeast of Mexico City the highway passes through the Puebla, second largest city of Mexico, center of many interesting sights and of much historical background One could tarry here for days without exhausting the trips of interest As the present paved highway through the Puebla to Tehuacan bears considerably to the east, it is likely that the present highway down to Cuautla, although it is not paved very far at present, will be the future Pan American route, because it is a more direct line southward

From Mexico City south to the Guatemalan frontier it is 975 miles by the present planned international highway route This section passes through Cuautla, noted for its natural baths, and through Matamoras and Nochixtlan to Oaxaca, capital of the state of the same name Oaxaca is noted for its friendly and picturesque Zapoteeans, whose women wear the colorful Tehuana dress These people are proud of their provincial distinction of dress, language and customs They are very interesting from the sociological point of view be-

Photograph by Herbert C Lanks

A JUNGLE STREAM AT SUNSET

THE PAN AMERICAN HIGHWAY CROSSES SCORES OF STREAMS ON THE WAY SOUTH THROUGH MEXICO ANY TIME OF THE DAY A STREAM CROWDED ON BOTH SIDES BY DENSE JUNGLE MAKES AN ATTRACTIVE SIGHT, BUT ESPECIALLY AT SUNSET

cause of a sort of matriarchal society. Oaxaca is colorful in many ways Everything is distinctive here For many who have the time and inclination it will be a worthwhile stopping place for some days when the paved highway route reaches this section. Outside of Oaxaca are the famous ruins of Mitla and Monte Alban, remains of an ancient Zapotecan civilization, interesting new vestiges of which are being uncovered each year

From the state of Oaxaca on through the isthmus of Tehuantepec, we pass into the large and little-known state of Chiapas, which borders on Guatemala In prehistoric times this state, which adjoins Yucatan and Guatemala, was the seat of a great Mayan civilization Scattered throughout the untraveled jungle of this sparsely populated state are many sites of ancient ruined cities of great archeological interest Most of the state lies in the humid and hot tropics It has considerable broken topography which, with many jungle streams, will make it interesting for natural scenic beauty and also important economically when its rich tropical land is opened by modern highway The energetic people of Chiapas realize the great importance of highway development for their progress, and are enthusiastically complementing the federal government work with their own efforts all along the route At the present rate of progress, two years should see the country opened up to highway travel and transport The route through this state passes through Juchitan, making a great inland sweep to serve the larger centers of Tuxtla, Comitán, Huixtla and then back to Tapachula near which it crosses the Guatemalan frontier into Malacatan

(*To be concluded*)

AN AMPHIBIAN GRAVEYARD

By Dr ALFRED S. ROMER

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LIVING amphibians—the frogs, toads, salamanders and their kin—are forms of modest size which are relatively unimportant in the animal life of modern times In the Triassic period, some 150 millions of years ago, their role was a more prominent one The oldest amphibians, of the late Paleozoic, had been of major evolutionary importance as the first vertebrates to emerge from the fish stage of evolution and become four-footed animals By Triassic times many of their descendants had reached the still higher reptilian stage of evolution, and dinosaurs, mammalian ancestors and other reptiles dominated the scene The older amphibian groups still survived, however, in the form of labyrinthodonts Many of these were of large size, and were roughly comparable to the modern crocodiles and 'gators in appearance and habits But they were a degenerate stock, with flattened heads and bodies and tiny legs, which indicate that they were incapable of emerging from the water.

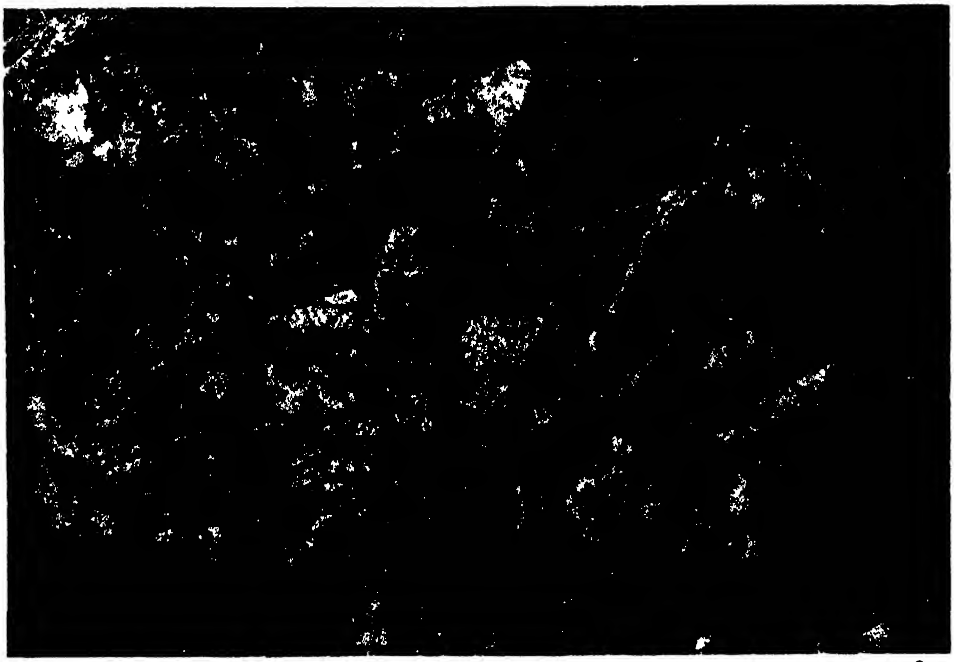
Such amphibians have been found in almost every region of the world In North America, however, they are far from common Despite extensive exploration of the Triassic, our museums contained perhaps but two dozen skulls of "native" members of the group

It was thus of interest when, in 1936, Mr and Mrs R V Witter, while engaged in a "scouting" expedition for fossil reptiles and amphibians for the Museum of Comparative Zoology, saw fragments of amphibian bone washing down the side of a small hill in Triassic deposits 16 miles south of Lamy, New Mexico The fragments were found to come from a bone layer extending some distance along the slope of the hill Such excavation as could be done in a limited time resulted in the discovery that the layer consisted of a nearly solid mass of bones, almost all of them pertaining to a single species of amphibian, *Buettneria perfecta* Time was lacking to do more than obtain a few skulls

Two years later the Witters returned to the site, accompanied by Dr T E White, and undertook the complete excavation of the deposit, a project sponsored by Dr Thomas Barbour, director of the museum. The rich bone layer extended 50 feet or more along the face of the exposure and some distance back into the hill It was covered, however, with a six-foot overburden, including a two-foot sandstone layer, which made the task of reaching the fossils a difficult one The sandstone was broken up with picks and a few judicious shots of dynamite The overburden was removed with a slip attached to the faithful, though decrepit, expedition flivver, and the bone layer exposed throughout

From the excavation about half a hundred good skulls were recovered, as well as large quantities of the prominent dermal plates of the shoulder girdles (clavicles and interclavicles) and numerous isolated elements of the backbone and limbs Fragmentary remains of skulls indicated the presence in the area of a total of about 100 individuals It seems certain that the deposit is but a remaining margin of a much larger area of deposition which before erosion must have contained the closely packed skeletons of many hundreds if not thousands of these large amphibians

Most of the bone layer was removed in small slabs containing but one or two skulls It was decided however, to attempt the technically difficult feat of bringing back for exhibition purposes a larger slab to demonstrate the nature of the deposit An area 6 by 8 feet was blocked out and the surface worked down close to the bones, which were hardened by liberal doses of shellac A trench was then cut around the block and boards



A SLAB, AS EXHIBITED IN THE MUSEUM OF COMPARATIVE ZOOLOGY

SHOWING THE NATURE OF THE BONE LAYER IN THE LAMY (NEW MEXICO) AMPHIBIAN "GRAVE YARD" THE SPECIMEN IS AN UNDISTURBED SAMPLE AREA OF THE QUARRY, SIX BY EIGHT FEET IN SIZE, CONTAINING THE SKULLS OF A DOZEN AMPHIBIANS AND NUMEROUS JAWS, SHOULDER PLATES AND OTHER REMAINS OF THESE ANIMALS

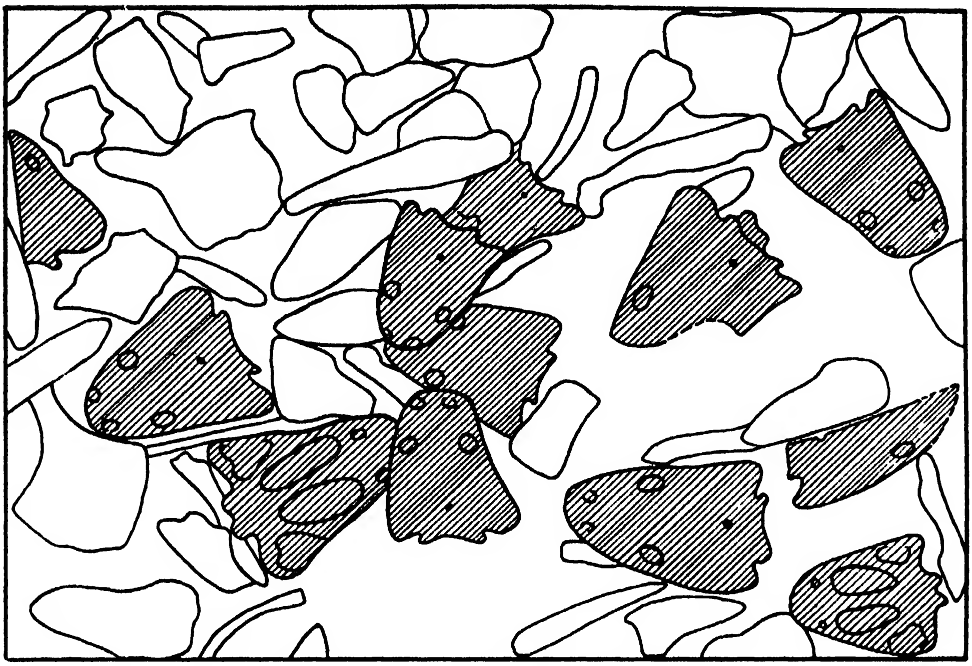
nailed together to form the walls of a permanent case for the specimen To preserve the slab intact, some 600 pounds of plaster were poured into the top and reinforced with boards and burlap Holes were drilled through the shale beneath the block and iron bars, secured to the sides, passed beneath it The specimen (now weighing about a ton) was then raised and turned over with jacks, muscles and a final pull by the car The bottom of the block was peeled down to the under side of the bone layer, this was reinforced by plaster and a bit of highway fencing; the bottom boards were nailed on and the box finally prepared for shipment The entire task of preparation and transportation to the railroad at Lamy was carried out by White and Witter unaided, the station master, however, felt it necessary to call in the entire section crew of 20 men to load the box on to the freight car [1]

The slab, as finally prepared by Witter in the laboratory and placed on exhibition in the Museum of Comparative Zoology, is shown in the accompanying photograph The bones are massed and frequently overlapping This one small area contained a dozen skulls and numerous shoulder plates and other bones, all strewn about in completely disarticulated fashion

This deposit is an excellent example of "mass death," a phenomenon discussed by Weigelt,[2] and of which a second (and geologically much more recent) Amer-

[1] We wish to express our gratitude to a number of local residents—Messrs Eldon Butler, C P Frank, C T Gould, Zack Gunter and Edward Young—for many kindnesses done the field party, to Messrs. Dobson and Fullerton, of Miami, Oklahoma, owners of the Eaton grant, for permission to excavate the quarry, and to Dr R G Fisher, secretary of the Science Commission of New Mexico, for a state permit for excavation

[2] J Weigelt, "Rezente Wirbeltierleichen," Leipzig, 1927



KEY TO THE ILLUSTRATION OF THE SLAB

THE SKULLS ARE SHADED, AND THE OTHER LARGE BONES (JAWS AND SHOULDER PLATES) ARE SHOWN IN OUTLINE

ican example is that of the Agate Springs (Nebraska) fossil quarry. Slabs from the Agate deposit are displayed in a considerable number of American museums. These are derived from a bone layer entirely underlying a small hill, in which are contained the tightly packed and disarticulated remains of thousands of mammals, most of them the twin-horned rhinoceros "*Diceratherium*." Matthew[3] has suggested that the Agate deposit represents a quicksand near a water-hole, in which animals were bogged.

The explanation of the present deposit must be of another nature. The bone layer is thin—but two to four inches thick—and is surely not a quicksand. More probably it represents the last remnant of a large area of water in which the amphibians dwelt. In Triassic times western Texas and New Mexico must have been a well-watered lowland, with numerous streams and pools. Presumably, however, it was subject to recurrent droughts—geologically ancient predecessors of "dust bowl" conditions. Under such circumstances the lagoonal areas in which the amphibians lived would have become greatly restricted. Since these animals were, as we have said, confined to the water, the gradual drying up of the pools would have resulted in crowded conditions in the remaining lagoons. Their food supply of fishes and other water-dwelling animals would have been rapidly exhausted, and starvation would have followed. Our deposit represents the last scene in the drama of drought—a shrinking residual pool, tightly packed with these amphibian monsters, starving survivors struggling about through the mass of rotting corpses of their weaker brothers. Eventually all would become quiet in the pool. The rains, when they returned, would bring down clay and sand to cover the skeletons and preserve the graveyard through the 150 millions or so of years that have since elapsed.

[3] *Natural History*, 23: 358–369, 1923.

NEW APPROACHES TO THE SCIENCE OF VOICE

By Dr. CARL E. SEASHORE
RESEARCH PROFESSOR OF PSYCHOLOGY, STATE UNIVERSITY OF IOWA

It is very significant that the scientific approach is practically the same for music and speech Both employ the same medium, are studied by the same types of instruments, by the same laboratory and art principles of technique and in the same spirit of a combined scientific and artistic attitude Furthermore, as a rule, scientific findings in one of these fields transfer in principle to the other. Science is, therefore, becoming a melting pot in which the two vocal arts are brought into mutual admiration, mutual understanding and mutual assistance

The science of voice draws upon many fundamental sciences, notably, physics, physiology, anatomy, anthropology, neurology and psychology, and it has become the function of psychology to integrate these basic scientific approaches into an applied science which we may call the *psychology of the vocal arts*

In this field, more has been accomplished in the way of fundamental contributions toward rigorous scientific procedure in the past twenty years than in all previous history This is due, in a large part, to the extraordinary progress that has been made in the field of acoustics for the promotion of the recording and the transmission of sound, which received its first impulse from the utilization of the vacuum tube technique We may therefore say that we are now laying foundations for a comprehensive science of voice and that nearly all the current approaches are new

For the purpose of this preview, let me ask the reader to imagine that he is invited into the psychological laboratory, equipped and devoted to a scientific study of these arts I shall not attempt to describe instruments or give technical results, but ask you to take the same attitude that you take in going through a museum, where you move from case to case and cast swift glances at strange animals and fascinating habitats. Nor will it be possible to distribute credit for inventions, because this is usually allocated among numerous cooperating agencies

I can merely offer you a series of labels with an occasional illustration to give you glimpses of the more fascinating vistas in this new territory of an applied science My catalogue will include eighteen items

I *The nature of the action of the vocal cords* There have been two main opposing theories, one to the effect that tone quality is determined basically by a segmental vibration of the vocal cords after the pattern of a violin string, and the opposing theory, that the harmonic structure of the sound is not determined by the vocal cords but by the resonance characteristics of the oral cavities This debate, centuries old, is now taken from the armchair into the phonetics laboratory, and we are coming into command of detailed pictures furnishing rich detail in regard to the action of the cords

You see a moving picture film (Fig 1) of the vocal cords in one complete cycle of the cords from closure through maximum opening and return to closure in the generation of a single sound wave These pictures can be submitted to harmonic analysis We now have the announcement that these pictures may be taken at the rate of as much as four thousand pictures per second, employing the same general technique as has been employed in the photographing of

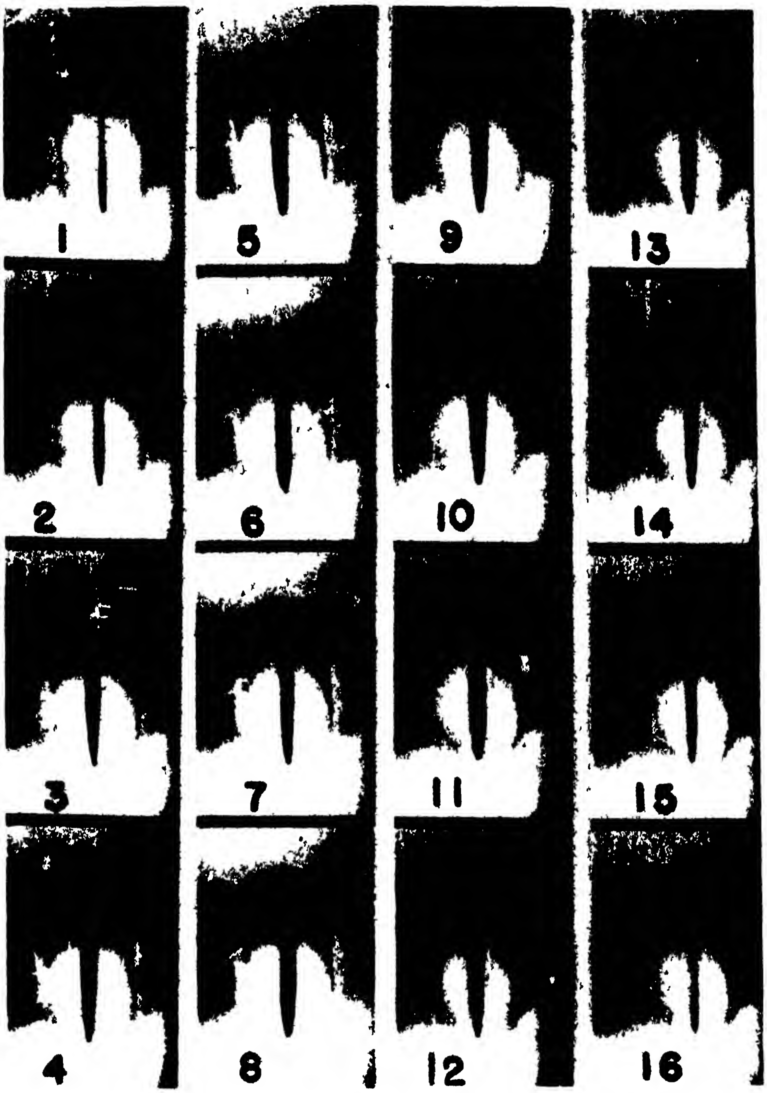


FIG 1 MOVING PICTURE OF ONE VIBRATION (16 FRAMES) OF THE VOCAL CORDS IN A BARITONE SINGER [1]

the flight of bullets A detailed study of such records is certain to answer once and for all the perpetual debate in regard to the function of the vocal cords

As is usual in controversy of long standing, there is some truth on each side, but the pictures now furnish positive proof that the vocal cords do vibrate in segments This picture shows that the resulting variation in the opening between the cords tends to correspond with the overtone structure of the tone to a considerable extent

II *The oral resonance* We have had for some time the x-ray technique, whereby, for example, the position of the tongue in the formation of different vowels has been demonstrated However, we know now that vowels in speech

[1] From Tiffin, Saetveit and Snidecor, *Quarterly Journal of Speech*, 24 1, 1–10, February, 1938

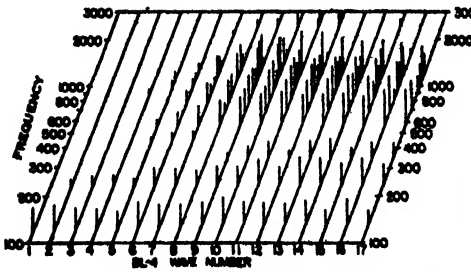


FIG 2. HARMONIC STRUCTURE OF THE VOICE IN THE VOWEL OF THE WORD "TOP" SHOWING PROGRESSIVE CHANGE [2]

FIG. 3. ONE SOUND WAVE IN A VIOLIN TONE

and music are not static but represent action patterns, as in Fig 2, and we now have the means of determining the rate and form of the changes in the oral cavities which determine, for example, an *a*, an *e*, and *i* or an *oo* The rate and form of change in the resonance cavities can be recorded in detail on an electrical polygraph

With these two series of data revealing the action of the cords and the cooperating action of the resonating mechanisms, we have the material in hand for an adequate description of tonal quality in terms of the physiology and physics, which underlie our hearing of a sound in cross section for the period of a single vibration, which we call timbre, and the progressive change for the duration of the sound, which we call sonance In terms of the physical correlates of these two factors, timbre and sonance, we can describe the nature of the sound as delivered from the mouth qualitatively and quantitatively This achievement is a cornerstone for the theory and the practice of the vocal arts

III *The oscillogram* We can now intercept the sound waves from the mouth by a high-speed moving picture camera which records in minute detail the actual form of each sound wave as it passes through space You see in Fig 3 a single wave in the sound of a good violin It is very complex, and when properly analyzed, gives us a complete picture of the harmonic structure for the period of a single vibration in that tone which is heard at the pitch of 196 cycles per second Sound waves of this kind have been recorded for a long time, but it is only within the last decade that the recording instruments have been so

[2] Black, "Archives of Speech," Vol 2, 1937, p 9

FIG 4 THE HENRICI HARMONIC ANALYZER

refined as to guarantee complete fidelity in the representation of the tone

In the laboratory, you may see now series upon series representing the form of the sound wave for each of the orchestral instruments at different pitch levels and at different intensities, and the same for bass, tenor, alto and soprano voices, and for characteristic speech sounds as well as for the vocal utterance of animals It is in the form of these sound waves that we preserve, transmit and analyze any sound into its component elements

IV *Harmonic analysis* The significance of wave form has been known for centuries in physics and mathematics and expressed in terms of what is known as the Fourier theorem, but it is only within the past few years that mechanical instruments have been designed for complete analysis of sound waves by automatic recording instruments, of which the Henrici harmonic analyzer is a good example (Fig 4)

When sound is fed into this machine, out of it will come, upon a series of dials, an exact statement of the overtone structure of this sound so that we can see exactly what partials or overtones are present, how they are distributed and how much of the energy of the whole tone lies in each one

Readings of this kind are put into the form of what we call a tone spectrum which reveals the exact structure of this tone at a glance. It is a graphic, quantitative, physical description of the tone involved in a given sound wave Fig 5 shows two series of tone spectra from the violin On this plan the quality of tone in speech and song may be represented descriptive of violin tones

Thus tone quality is taken out of the region of mystery, confusion and ignorance, which has prevailed in the vocal arts and inceptive sciences, and is made measurable, verifiable, namable and explainable.

V *The complete and adequate recording of performance* All sounds, musical and unmusical, are represented by four factors, namely, the frequency, the amplitude, the duration and the form of sound waves As correlates of these four, we have the four fundamental attributes of sounds that we hear and sounds that we produce, namely, pitch, loudness, time and timbre The recognition of this fact is an enormously large step in making scientific recording adequate

If, in your imagination, you follow me in the laboratory, you will see the following set-up for the recording of speech or music in terms of these four factors The singer stands in an acoustically treated music room before a microphone, as in a radio studio, and sings or speaks in a perfectly natural manner, with or without an audience In an adjoining room, a complete record of the performance is made as follows in the time that it takes to sing or read a selection

There is a battery of three specially designed motion picture cameras One records the frequency or pitch, another records the intensity or dynamic values, and the third records the wave form or timbre And all three of these cameras record synchronously against time, thus giving us a complete record of every element that enters into the tone At the same time, a recording machine makes a permanent phonograph or film record of the rendition, exactly synchronized with the moving pictures of the sound waves, so that for scientific purposes the actual sound can be reproduced in whole or in part as often as is desired and related to the phonograph record of the sound waves If for any reason it is desired in the study of interesting characters, we may add to these records a moving picture of the actual outward behavior of the singer or speaker in the act

All these cameras and recording devices have been remodeled during the past five years and can now be said to

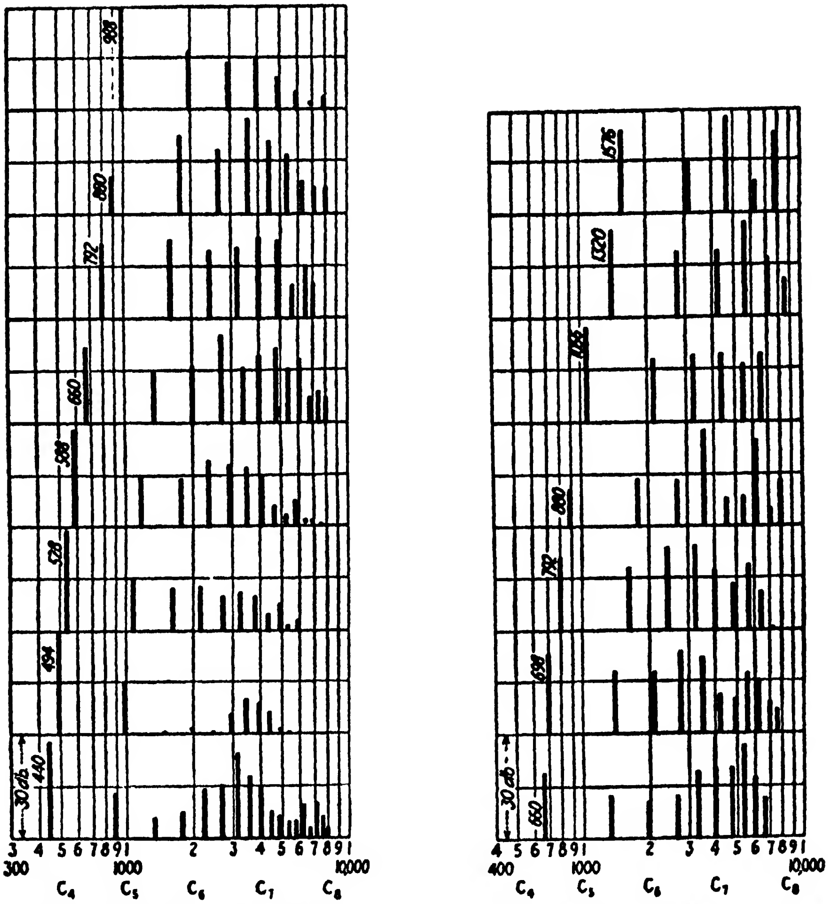


FIG 5 *Left*, TONE SPECTRA FROM THE A-STRING OF THE VIOLIN,[3] *right*, SAME FOR THE E-STRING

have reached the perfection which makes them thoroughly adequate for all scientific and artistic purposes Therefore, this is the first step taken in the laboratory for the complete recording of performance

VI *The annihilation of time and space* In the commercial field, these principles have recently attained a high degree of perfection in the now conventional talking films by employing high quality recording outfits, so that now the performance of any artist may go into a permanent record of very high scientific and artistic value Such films in their original untouched condition can now be taken into the laboratory for the most refined scientific analysis This gives us an unlimited field of riches in the source of materials for scientific study.

The same process of high quality recording has annihilated distance so that the recording may now be done in the most remote parts of the earth and brought home for deliberate scientific study in the laboratory. As soon as the producing companies observe easily available scientific precautions in selection and recording, we may see the dramatic action in song and speech and dance of the most primitive peoples and measure and describe the character of their performance in minutest detail.

If we had not suddenly become so

[3] From Small, in Seashore, "Psychology of Music," McGraw-Hill, 1938, p. 217.

familiar with the marvel of moving pictures, this scientific invention would certainly be regarded as one of the Seven Wonders of the World

VII *The performance score* But with all this collected mass of material at hand, we had to await the invention of an adequate medium or language for the effective representation of all the detailed measurements

A section of the performance score for the singing of "Ave Maria" illustrates the principle (Fig 6) The performance score is very much like the conventional score except that in place of a mere note showing what should be sung, we have a graph showing exactly what was sung as to pitch, loudness and duration of the tone The tone quality must be shown in a more detailed score It is really astonishing how such an enormous number of exact measurements can be transformed into a compact score, scarcely occupying any more space than a conventional music score

The same principle of performance score is equally adaptable to speech, as we see in a performance score of a dramatic reading (Fig 7) Literally thousands of measurements go into the construction of one of these performance scores, but the final picture is a generalization which has meaning for the vocal arts

VIII *The voice and the room* Even in the modern acoustically treated studio, the performance is complicated by the fact that what we hear is always the tone as delivered from the voice plus the resonance characteristics of the room In ordinary parlors, theaters and concert halls, this modification is a great handicap to the artist

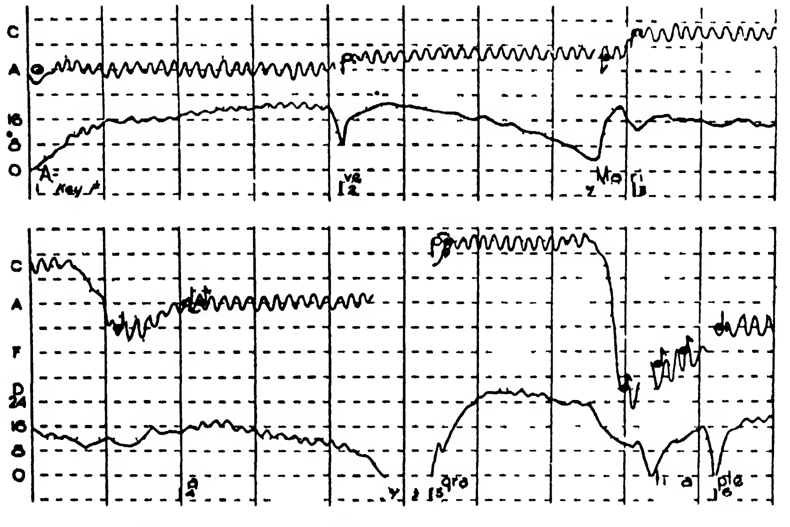


FIG 6. SECTION OF PERFORMANCE SCORE OF BACH GOUNOD "AVE MARIA" AS SUNG BY STARK UPPER GRAPH DENOTES PITCH, LOWER, INTENSITY, TIME, DOTS AND DASHES IN 1/10 SECOND. VERTICAL SPACES ARE IN SEMI TONES FOR PITCH AND IN 4 DECIBEL STEPS FOR INTENSITY [4]

We can now separate the study of the performance of the room from the performance of the singer. To do this we record two performances of the same act, a song or a speech The record is first made in a musically adapted studio whose resonance characteristics have been measured and are under control Then the performance is repeated in a "dead" room Now a dead room is one that has been sound-proofed by the most recent

[4] H G. Seashore, "Iowa Studies in the Psychology of Music," Vol. 1, p 17

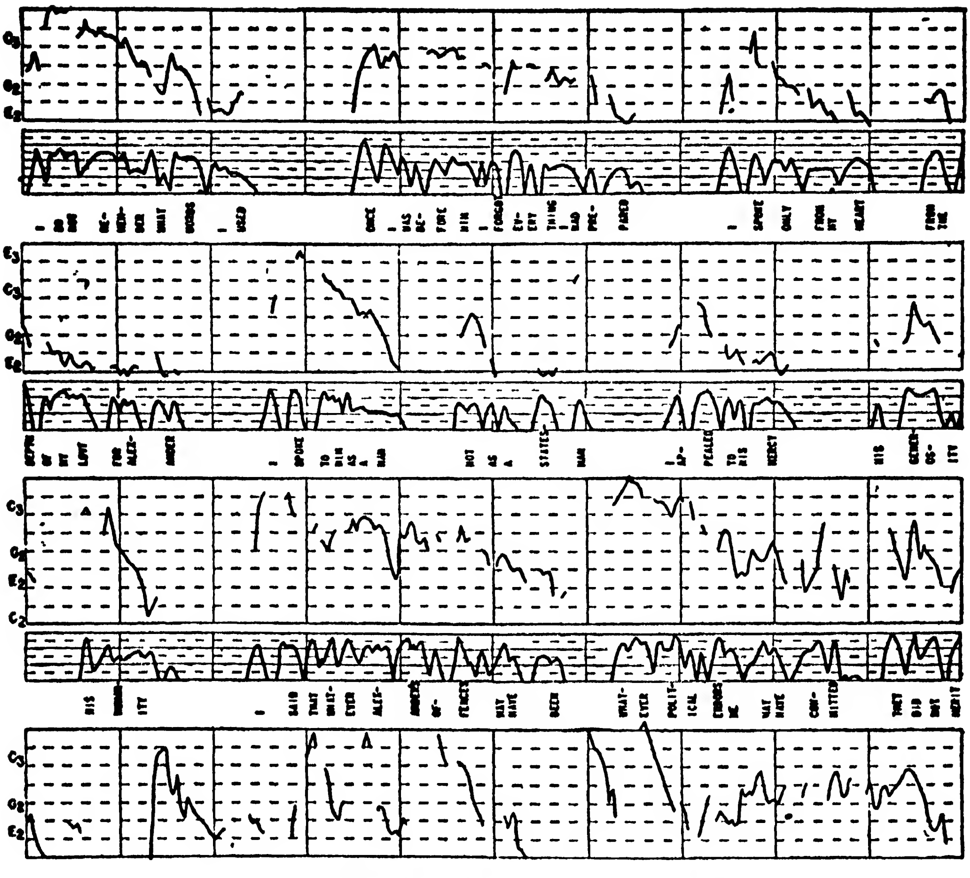


FIG 7. PERFORMANCE SCORE OF SPEECH[5] TERMINOLOGY SAME AS IN FIG 6

methods so as to exclude disturbing sounds from outside and eliminate all vibrations from any part of the room or any of its contents, with the result that, when the song or speech is rendered in this room, the record will be entirely free from the effect of the ordinary room resonance or accessory sounds

That the sound in the dead room is radically different from the sound we hear in the studio is quite evident to any one who has listened to the room characteristics of the voices that come over the radio from different types of recording studios or in concert halls.

This procedure of eliminating the room resonance is a characteristic step in the scientific process of eliminating accessory and disturbing factors It creates a new interest in the exceedingly important problem of how to control the acoustic qualities of rooms and the contents of rooms in which man is called upon to sing or speak The tone spectra for each of these two conditions contain exact descriptions of the two tones for comparison in terms of harmonic structure, as in Fig 5

IX *The phrasing score* There is a refinement of the performance score which we call the phrasing score of which we can have very many varieties, both in music and in speech In Fig. 8 is shown a section of a phrasing score from a rendition by Menuhin

The principle is here the same as for

[5] J M Cowan, "Archives of Speech," Supplement, 1936

singing. No singer or player sings in true pitch, even dynamics, metronomic time or uniform tone quality If he did, he could not possibly be regarded as a good singer The beauty in music and speech lies in the artistic deviation from the regular—from true pitch, from even dynamics, from metronomic time and from pure tone We can, therefore, measure the artistic qualities of any vocal performance and express it in terms of the amount of deviation from the base in each of these four characteristics

Thus, this very ethereal element of personal interpretation which we technically call phrasing is exposed in objective form, qualitatively and quantitatively In terms of the phrasing score, we are able to express in standardized terminology exactly how one musician's interpretation of a phrase differs from that of another

X *The rhythm of poetry* Technique of this kind enables us to deal objectively with hoary problems of armchair debate, such as the relative role of time and stress in poetry The so-called accent in poetry is not always obtained by stress, nor by time, and these two factors are interchangeable to an astonishing degree, so that we can give the feeling of time through stress or the feeling of stress through time in the artistic reading of poetry A score for this purpose would be analogous to Fig 7

By recording the artistic reading of a poem and expressing it in terms of a phrasing score, we are for the first time in history enabled to submit the time-worn theories and sanctions of rhythm in poetry to the acid test In this, most astonishing and revolutionary findings occur, because here, as in music, the listening ear has been deceived and has not been corrected by objective check We are therefore facing a thorough revision of artistic theory and practice in poetry and prose

By the same techniques, of course, we can deal now with the song of birds, the cry of the infant and the laughter of merrymakers

XI *The action current technique* We are anxious to know what musculatures are involved in phonation There are scores of them, and until recently we have had little more than guesswork in regard to their operation By means of the action current technique we can now trace the origin, the course and the point of discharge of a nerve impulse that energizes the muscle We can show the time-order, the intensity and therefore the relative dominance of various nerve impulses in the vocal act This procedure is now best illustrated in the measurement of brain waves

XII *The criteria of good voice* On the basis of scientific analysis, we are beginning to catalogue the criteria of good voice, such as richness in tone quality, range of pitch inflection, range of dynamic inflection, rhythm and flexibility Each of these qualities of voice is now subject to exact measurement, analysis and internal classification Carrying power, for example, is not mere volume or loudness but the right choice and adequate artistic control of a score of specific factors each of which can be isolated and measured On the basis of such information, voice training can be organized with specific and tangible goals

XIII *The vibrato* The vibrato has been recognized by musical authorities as one of the four basic qualities of a good voice It is one of the 30 or 40 recognized musical ornaments Until the vibrato was taken into the laboratory, there was the utmost confusion, ignorance and falsehood perpetrated about this so-called tender quality of music and speech The periodic waves in the graph for pitch and loudness in Fig 6 describe the vibrato in that performance But the laboratory scientist has discovered what the vibrato is, what kinds of vibrato exist, the frequency and conditions of its use, its role in the ex-

pression of emotion, norms of performance, actual and ideal, methods of training and scores of other features. And, in the mastery of this single ornament in music and speech, vastly greater contributions have been made to allied and implied interests both in the field of psychology of art and general psychology A discovery in applied science always receives something from the mother science and gives something back to it

Fig 9 shows the inside of a beautiful tone involving the vibrato and indicates in the form of sound waves and can study the artistic tone as a physical structure in the same way as we can observe the delineations of a work of architecture

The vibrato, for example, is one means of expressing feeling By the very technique employed in measuring the vibrato, we can measure the expression of an endless variety of forms of musical expression, usually in terms of the nature and the extent of the artistic deviation from the mechanical or unemotional

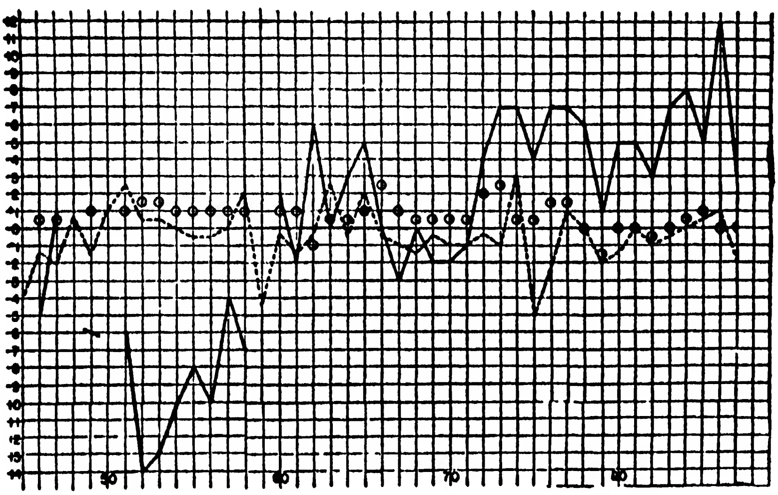


FIG 8 VIOLIN PHRASING SCORE OF THE "TZIGANE" (RAVEL) AS PLAYED BY MENUHIN THE ZERO LINE DENOTES RIGID TIME DEVIATIONS ARE SHOWN FOR PITCH BY CIRCLES IN 1/10-TONE STEPS; FOR INTENSITY BY SOLID LINES IN 1-DECIBEL STEPS, AND FOR TIME BY DOTTED LINES IN 1/10 OF A SECOND STEPS. ROWS AT THE BOTTOM INDICATE ORDER OF NOTES [6]

how timbre vibrato results from changes in partials In other words, it describes the change in quality of the tone for a period of one third of a second

XIV *Measurement of the expression of emotions* We must distinguish between the having of an emotion and the expression of it The expression of an emotion through voice is recordable, and scientifically describable both qualitatively and quantitatively, because, in the laboratory, we have under control all the media in which the emotion is expressed

[6] Small, "University of Iowa Studies in the Psychology of Music," Vol 4, p 196.

XV *The measurement of illusions.* All art is illusion At any rate, it is the largest factor in all artistic experience, and this fact has contributed to the general feeling that art is something ethereal, intangible and mystic. We now have countless illustrations of measurement of illusions which function in the production and the hearing of a beautiful sound The vibrato as a whole is one grand complex and beautiful expression of the operation of the laws of illusion. Dynamic phrasing, as in rhythmic speech or song, is revealed in the discovery and evaluation of the illusions which operate

in creating the feeling of rhythm. Practically all illusions which operate in the vocal arts can be isolated and measured in the artistic object, the tone A tone of a given frequency involves illusions of pitch, dependent upon the relative intensity, relative duration and the rela-

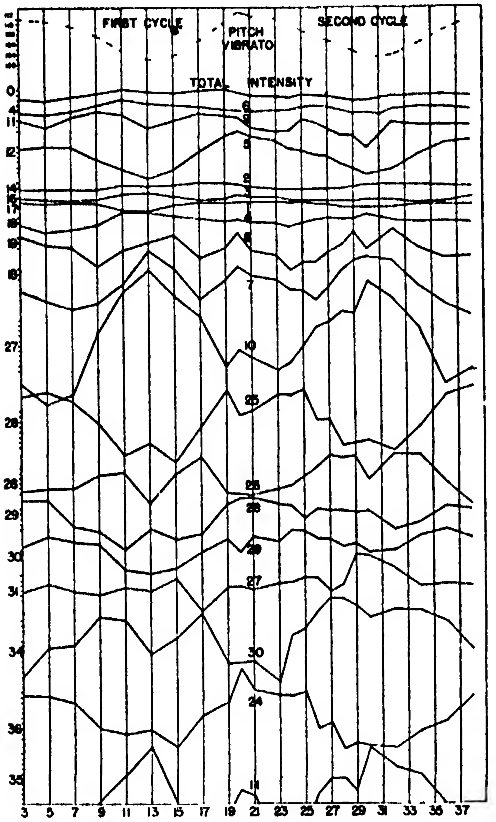


FIG. 9 THE HARMONIC STRUCTURE OF A BEAUTIFUL TONE TONE COVERS TWO VIBRATO CYCLES, ONE-THIRD SECOND PARTIALS ARE GRAPHED FOR INTENSITY AND NUMBERED AT THE CENTER PITCH GRAPHED FOR EACH PARTIAL WOULD BE SAME AS IN DOTTED LINE STRENGTH OF PARTIAL IS INDICATED BY ITS RELATIVE NEARNESS TO THE BASE O ANALYZED WAVES ARE NUMBERED AT THE BOTTOM [7]

tive richness of the tone A tone of 444 vibrations per second does not always mean the same pitch because there are numerous well-known illusions which modify the pitch that we shall hear and, strange as it may seem, the measurement of the illusion becomes quantitative because all we need to measure is the extent to which the physical tone is different from what it seems to be as determined by a matching process

XVI *The measurement of talents.* With the rapidly growing analysis of the nature of capacities and abilities or natural resources, both physical and mental, which operate in the vocal arts, we have laid the foundation for the measurement of talents and, to a limited degree, of prediction of possible extent and success in training The most striking finding to the scientist who penetrates into this area is the enormous richness in the hierarchy of talents which, together, operate in the vocal arts The still popular notion is that we can secure what I have called an omnibus measure, or a single M Q, which shall designate talent for singing or dramatic art That point of view I regard as misleading. Whenever we adopt a scientific point of view, we must begin to make sacrifices by isolating and observing one factor at a time and limiting our conclusions to the factor measured under control Splendid progress is being made in this direction so that we can now talk in a fairly standardized language in terms of recognized concepts and with reference to differentiation among a variety of objectives in advising children and youth in regard to musical and dramatic education, choice of vocation and, what is much more important, the selection of an avocation

We now have norms for the distribution of capacities within a given talent. The average ear can hear a pitch difference of 1/17 of a tone, a high talent may hear a 1/100 of a tone or less, a very poor talent may not hear a semitone.

XVII *The science of esthetics.* Esthetic theories in the vocal arts are practically all of the armchair variety They range from the garrulous babblings of persons who have professional services

[7] Borchers. From Seashore, in *Music Educators Journal,* October, 1936

to sell to the abstruse cogitations of philosophers quite remote from tangible things on this earth The coming esthetics will be built upon scientific experiment All theories which present any degree of plausibility must be reviewed and chastened through the cutting tool of experiment, and the organic structure of a theory of the beautiful must be based upon the solid foundations of describable, verifiable and significant facts Such an esthetics is now in the making In this process, many hoary and highly cherished theories must be scrapped To pass from speculation to a scientific esthetics by a deepening insight of thorough experiment will be like passing from star gazing to astronomy

XVIII *Scientific training* We are facing two radical innovations in the art of training the singing and speaking voice First of these is the recognition of an adequate analysis of what constitutes voice and reduction of this to the fundamental elements which are its determinants This is necessary in order that we may note what we are doing when we train, for example, for flexibility and dynamic control in carrying power, richness or in any other specific factor The future teacher of voice will not shoot at the blue sky of voice but will direct attention to one factor at a time in order that the pupil may become systematically and economically voice-conscious The other factor is that we now have available in the laboratories instruments by which the training may be aided by making the sound visible so that the singer or speaker can see exactly what its pitch is, exactly what its dynamic value is, exactly what its phrasing duration is and exactly what its tone quality is For each of these we could set up models so that the pupil who is being trained will stand before a recording structure and see himself sing just as he sees the movement of his lips in the mirror The tonoscope was a pioneer instrument in this field

The great advantage of this is, of course, the fact that he trains for one specific control after another until that becomes automatic, and shortens this time by training against a check so that after every trial he knows how near he came to the true goal It works in accordance with the established fact that learning proceeds most effectively when we have a specific goal and have means for knowing to what extent we are right in each trial

SPANISH METHODS OF CONQUEST AND COLONIZATION IN YUCATAN, 1527-1550

II. THE CONQUEST AND INITIAL COLONIZATION

By Dr ROBERT S. CHAMBERLAIN

THE CARNEGIE INSTITUTION OF WASHINGTON

THE Crown desired that the New World be gained by peaceful means to the extent possible and required that only just war be made on the natives There is little need to point out that this was a theoretical and pious, if at the same time wholly sincere, intent, and that in practice it was frequently set at naught It is one of the points, however, in which the characters and purposes of individual *conquistadores* determined the nature of conquest in a vital manner, giving to certain conquests a different aspect than that taken by others The acts of Balboa as opposed to those of Pedrarias Dávila in the area of Panama and the conduct of the conquest of Mexico by Cortés as compared to that of Peru by Francisco Pizarro illustrate this point It may be stated here that Alvarado offers a contrast to Montejo within the Maya area, the former, at least as we know him at this time, was ruthless and showed little regard for the natives, while the latter was moderate and sought, in the main, to protect them Before passing on, it should be mentioned that just war was a matter of deep concern to the Castilian monarchs and that its nature was the subject of prolonged debate and thought Furthermore, the *requerimiento,* or "requirement" by which the natives were summoned to allegiance to the sovereign of Castile and the acceptance of Christianity, although it has frequently been scoffed at, was for the Crown much more than a hollow legalistic formula and, based on a deep philosophy, represented a desire to comply with the demands of divine and human law.

There is every evidence that the *Adelantado,* Montejo the Younger, and Montejo the Nephew observed not only the form established by the Crown, but also the intent to a surprising degree Indeed, his mildness, forbearance, desire to avoid warfare when possible and the trust he placed in the sincerity of certain of the *caciques*, or native rulers, who gave allegiance while biding their time to rise in revolt upon occasions proved extremely costly to the *Adelantado*

From his first landing at Cozumel in the autumn of 1527 through the Maya revolt of 1546 the *Adelantado,* Montejo the Younger and Montejo the Nephew wherever possible sought to bring the Indians to acceptance of the dominion of the King of Castile without resort to arms Moreover, they formed alliances with native rulers whenever such could be done, taking advantage of the rivalries and enmities which existed among the several *cacicazgos*, or native states, and placing in effect the principle of divide and rule The allies thus gained furnished auxiliaries, supplies and burden-bearers and measurably aided the Castilians There was in the conquest of Yucatan from first to last, with the exception of the final reduction of the provinces of Uaymil-Chetemal, relatively little of the ruthlessness which characterized certain of the conquests in the Americas The Montejos, furthermore, took surprisingly little vengeance on natives who rose in revolt sometimes repeatedly, after having submitted

The first act of the *Adelantado* upon reaching Cozumel in the autumn of 1527 was to establish friendly relations with the natives of the island On crossing

to the mainland and founding a town at Xelhá, he attempted to win the natives to amity, but without great success. In moving northward along the coast, Montejo temporarily established his forces at Belmá, where a friendly reception had been prepared by the lord of Cozumel at his instance. There, having entered a heavily peopled area, he first placed the policy of peaceful reduction in operation on a large scale, and, calling together the *caciques* of a wide district, he secured the allegiance of many. Notwithstanding his desire to avoid war if possible, he conducted a military demonstration before the native lords that they might fully comprehend the force of which he disposed and ponder the alternative to acceptance of Castilian dominion. Moving to the port of Conil, he largely repeated his acts while at Belmá.

Serious resistance was first encountered at the great city of Chauac-há. The Maya, after receiving the Castilians in peace, turned on them, but were heavily defeated. They then sued for peace, and the *Adelantado* received the allegiance of the rulers, without exacting punishment. A second great battle was fought at Aké, another large city not far distant from Chauac-há, the natives evacuating the place and then returning to the attack. The Castilians won a complete victory and the *Adelantado* then called the *caciques* of the general area before him and received their submission. These hostilities, from all evidence, were initiated by the natives, and the *Adelantado* throughout this first phase of the conquest refrained from making war whenever the natives received him in peace and accepted Castilian dominion.

During the second phase of the conquest the *Adelantado* and his principal lieutenants, Alonso Dávila and Montejo the Younger, continued the same policies. While in Tabasco the *Adelantado*, apparently through a mission, secured the friendship of the warlike Couohes of Champotón, who had inflicted a sharp defeat on Hernández de Córdoba in 1517, during the latter's voyage of discovery, and thus prepared an amicable reception for the Castilians when they arrived at that point. Upon reaching Campeche Montejo convoked the *caciques* of the region in an attempt to obtain their allegiance without employing force, informing them of the declared purposes of the Crown and of his own aims. In this he was at least in part successful. When Montejo the Younger was sent to the northern provinces to reduce the area and found a city, employing peaceful methods and playing on the rivalries of the native groups, he at once secured the friendship and close alliance of the powerful Pech and Chel lords and later the alliance of the Xiu of Maní. An attempt was made to win the warlike Cupules by peaceful means upon the founding of Ciudad Real at Chichen Itzá, but without lasting success, and they and other groups of the central area soon united to drive the Castilians from the region. The Pechos, Cheles and Xiu, notwithstanding the defeat of the Castilians, remained their faithful allies.

On reaching Campeche at the opening of the final conquest, Montejo the Younger, pursuant to the formal instructions given him by the *Adelantado*, called the *caciques* of the province before him and received their allegiance, and either at this time or shortly after, certain of the Pech rulers and representatives of the Xiu also gave allegiance. Lords of these two latter groups reaffirmed their acceptance of Castilian dominion at later dates, the Xiu renewing their close alliance, and Chel and other rulers also voluntarily came to obedience. Certain of the lords of Acanul refused to heed the original summons, and were quickly forced to accept Castilian dominion. The peoples of the area of Mérida, founded on the ruins of the once great city of T-hó, however, rejected the Castilian demands and

resisted stubbornly, despite persistent efforts to win them to peace, and were reduced only after extensive military operations After the district had been pacified, great efforts were made to establish a condition of stability, and, as many Indians had abandoned their towns, a carefully planned system of trade and supply was established to accustom the natives to the Spaniards, lessen their fear and induce them to return to their homes This policy achieved considerable success

Montejo the Nephew was designated by the *Adelantado* to conduct the conquest of the central and eastern *cacicazgos*, which included the most warlike of the Maya, the Cupules and the people of Cochuah. He and his captains strove to secure the peaceful reduction of the districts concerned, with success in the provinces of Chikinchel, Ekab and Cozumel and limited results in the province of the Tazes, but with utter failure in the *cacicazgos* of the Cupules and Cochuah The Cupules and the people of Cochuah offered fierce resistance, rising repeatedly, and it was only after prolonged and bitter warfare that Montejo the Nephew, with the cooperation of Montejo the Younger, overcame them

It can be stated that in the main the Montejos made war only after all methods to win the Indians by peaceful means had been exhausted, and, upon the failure of such efforts, after the *requerimiento* had been issued and rejected, or in defence In other words, they consistently waged just war as defined by the Crown and in accord with the ordinances and policies of the sovereign. More than half of Yucatan, including certain of the most populous areas, was won by peaceful means or with but slight military effort, only the provinces of Chakán, Sotuta, the Cupules, Cochuah and Uaymil-Chetemal resisting to the end As has already been indicated, such policies were, over and above being legal obligations, in consonance with the desires, aims and characters of the Montejos The conquest was consequently achieved, with the exception of the reduction of the provinces of Uaymil-Chetemal, with a minimum of the harm to the natives which accompanied the subjugation of many parts of the Indies There were specific instances of ruthlessness, to be sure, but they were relatively few and isolated For instance, during the final campaigns, in Cochuah and the province of the Cupules a number of women and children were held as hostages or for enslavement, a limited number of natives taken with arms were hanged, and certain religious and political leaders of the Cupul center of Zací and of other areas were apparently executed summarily by Montejo the Younger and Montejo the Nephew and their chief lieutenants, and, in the area of Mérida, a subordinate captain, acting wholly on his own initiative, imprisoned a number of *principales* in a house, which was then burned, the native lords perishing The only campaign which was accompanied by systematic ruthlessness of a wholly wanton nature was that of Gaspar Pacheco, his son Melchor and his nephew Alonso in Uaymil-Chetemal Gaspar Pacheco was commissioned directly by the *Adelantado* to reduce the southern provinces, and, falling ill after initiating operations, he placed the conduct of the campaign in the hands of his son and his nephew This conquest was one of extreme excesses The natives, who resisted stubbornly, were slaughtered without mercy and the province was laid waste Many of those of the natives who succeeded in escaping fled beyond Castilian control Relatively heavily peopled at the outset, the area became largely depopulated Montejo the Younger and Montejo the Nephew did not approve the acts of the Pachecos, but had no control over them, as they held authority directly from the *Adelantado*, who was absent in Honduras-Higueras The re-

duction of Uaymil-Chetemal as contrasted with that of the remainder of the peninsula makes clear in striking fashion the manner in which differences in the characters and purposes of individual *conquistadores* could determine the nature and methods of conquest

During the Maya revolt of 1546, which centered in the province of the Cupules, the *Adelantado,* Montejo the Younger and Montejo the Nephew continued, in the main, their moderate policies, even in face of the greatest provocation, as the natives killed all Castilians and Indians friendly to them who fell into their hands In this instance, however, the sole one as far as can be ascertained, the *Adelantado,* after inquiries had been conducted, caused some five or six of the religious-political leaders of the revolt to be burned After the suppression of the revolt he convoked the *caciques* of a wide area at Mérida and sought to win them to friendship, solidify peace and restore normal conditions It is to be noted, furthermore, that the captain despatched by Montejo the Nephew to quell the revolt in the southern provinces was in his instructions specifically directed to secure obedience by peaceful means if possible This he succeeded in doing

The cruelties and excesses incident to the conquest and pacification were made the subject of charges, many highly exaggerated, placed before the Crown by the political enemies of the Montejos in Yucatan and the Franciscans and through the *residencia* of the *Adelantado* These charges were utilized by the sovereign in removing the *Adelantado,* his son and his nephew from authority

Enslavement of natives in accord with then current royal ordinances was authorized by the *capitulación* of 1526, but such practice was later forbidden by the Crown and was definitively prohibited by the New Laws While enslavement of natives taken in war was carried out in Yucatan, the numbers involved do not appear to have been great In this the Montejos observed the royal ordinances regulating enslavement which were in effect in 1526, although standing on the provisions of the *capitulación,* they carried on the practice after it had been forbidden by ordinances which the Crown intended to be of general application

During the first phase of the conquest slaves were apparently taken on the east coast by Dávila after Montejo had departed for New Spain, but they could not have been many in number, nor would it appear that, because of the isolation of the expedition, they could have been taken from the peninsula In the second phase of the conquest slaves assumed definite economic importance in view of the lack of gold and silver in Yucatan, and Indians were enslaved in unknown numbers Some were shipped to New Spain, but acting in conformance with the changed policy of the Crown, the *Audiencia* freed them The *Adelantado* was thereafter unable to secure specific official permission to enslave natives, despite his petitions, which were based on the patent of 1526 During the course of the final conquest, notwithstanding Crown policy, natives were again enslaved for economic reasons Ultimate approval by the Crown was obviously hoped for. The colonists desired to conduct an unlimited slave trade, but Montejo the Younger, despite pressure and dissatisfaction with his policy, refused to sanction such practice and strictly limited the commerce through licenses. Moreover, he freed a number of women and children who had been held for official branding A certain number of slaves were sent to New Spain under the policy of Montejo the Younger, but they were immediately liberated by the viceroy Incomplete *hacienda* records indicate but 241 as the number of slaves legally branded during the final conquest The question of enslavement without branding remains open, however, and it

is clear that slaves were sold within Yucatan. During the Maya revolt Indians appear to have been enslaved, especially by native auxiliaries under their own customs. After the conclusion of the revolt, however, the *Adelantado,* in conformance with royal legislation, freed such natives as had been made slaves.

Charges that tens of thousands of slaves were taken from Yucatan during the course of the conquest were brought against the Montejos from several sources, and in the *residencia* of the *Adelantado* it was charged that "great numbers" were enslaved during the final conquest and the Maya revolt. These latter charges when examined reveal that the actual figures indicated by those who testified in the *residencia* do not exceed two to three thousand. Such documentary sources as exist indicate that relatively few Indians were enslaved in Yucatan, that in enslaving natives the Montejos, acting on the *capitulación* of 1526, observed the ordinances regarding slavery which were in effect when the patent was granted, and that, when it was made clear that the Crown intended that the prohibition of enslavement should apply generally, they complied.

True colonization and political and economic development were throughout the objectives of the *Adelantado,* his son and his nephew. In his petition to the Crown for authority to conquer and colonize Yucatan the *Adelantado* emphasized his belief that it was strategically located with regard to the development of trade and the expansion of efforts for general reduction and settlement. Over and above that, he stated his mistaken belief that the land was rich in gold. The first expedition to Yucatan consisted of some 250 to 300 men, exclusive of mariners, and shortly after reaching the east coast the *Adelantado* caused his ships to be wrecked to prevent possible retreat and to add the sailors to his forces. Furthermore, en route to Yucatan he arranged that supplies and reinforcements be sent from Santo Domingo. Upon reaching the east coast, he immediately founded the town of Salamanca, and, as the location was unhealthful and the anchorage inadequate, he thereafter made every effort to locate favorable sites for permanent settlement and port facilities, passing to the distant Río de Ulúa in his search. The transfer of operations to the west coast was primarily determined by the desire for facile communication with the large centers of colonization in New Spain and the existence of adequate harbors in Tabasco. Upon being given authority over Tabasco, he pacified the province and preserved it from abandonment as a condition essential to the colonization of the peninsula.

During the second phase of the conquest the *Adelantado* disposed, from first to last, of from four hundred to five hundred men. Two towns, Salamanca, at Campeche, and Villa Real, at Chetemal, and one "city," Ciudad Real, at Chichen Itzá, were founded. Villa Real, from which the Spaniards were soon driven, was established with thirty to fifty *vecinos,* or citizens, by Alonso Dávila, and Ciudad Real, established by Montejo the Younger, with one hundred to two hundred *vecinos,* was transferred to the port of Dzilán, on the north coast, when the Spaniards were driven from the interior. The number of colonists in Salamanca, the base of operations, varied from about fifty to perhaps one hundred. Some three hundred to four hundred soldier-colonists were involved in the final conquest, and by 1545 San Francisco de Campeche had perhaps fifty *vecinos,* Mérida over one hundred, Valladolid between thirty and forty, and Salamanca de Bacalar perhaps fifteen to twenty. In 1533, when the colonization of Yucatan seemed assured, the *Adelantado* and municipal governments, to further permanent settlement and development, petitioned the Crown for confirmation of the temporary exemptions from certain taxes and duties and for confirmation of the privileges and grants of land as stipulated

in the *capitulación* of 1526, and this action was repeated upon the final conquest, the Crown assenting The attempt of the *Adelantado* to settle the area of the Golfo Dulce, his final effort of colonization, and one to which he attached great importance, placing its conduct in the hands of his son and his nephew, appears to have been directed primarily toward commercial development, as Nueva Sevilla was established on the route between the North Sea and Guatemala, which the Crown had considered establishing as that which should supply the latter province and adjacent areas

The founding of towns was carried out according to fixed legal formulae The highest authorities directly involved named the original members of the municipal government, the principal of whom were the *alcaldes, regidores* and *alguaciles,* citizenship was formally granted, the town was laid out, plots, *solares* and *caballerías* were assigned to each *vecino* for his dwelling and for agricultural purposes, communal lands were set apart, the district of the town was delimited, and the Indians were partitioned among the citizens in *encomienda.* The erection of public buildings, churches and dwellings was carried to a conclusion as rapidly as possible, Indians supplying the labor.

The members of the expeditions with which the *Adelantado* conducted the first two phases of the conquest were primarily adventurers who desired sudden wealth Early in the second phase it became apparent that Yucatan possessed no gold and silver and that it was purely an agricultural province in which the settlers would be forced to be content with *encomiendas* and with *haciendas,* simple industry and commerce, which required solid and prolonged effort and a true colonizing spirit Yucatan was regarded as a "poor province" by the soldiers These factors were the fundamental causes which led to the failure of the second phase of the conquest The *Adelantado* himself, it must be stated, was keenly disappointed at the absence of precious metals With the experience of 1531 to 1535 before him, it appears that the *Adelantado* and Montejo the Younger made definite efforts to secure for the final conquest soldier-colonists who would be content with *encomiendas* and would put forth efforts to develop agriculture, grazing, industry and commerce. Indeed, the reputation of Yucatan as a "poor province" was widespread and impeded the ready procurement of men for the final conquest Those who did present themselves consequently tended to be of stable character and of a truly colonizing type A considerable proportion were already married, and many others married shortly after the conquest. There were some, notwithstanding, who after the founding of Mérida, desired to leave the province, but such action was forestalled by Montejo the Younger. Cattle, sheep, hogs, horses and mules were brought in and European trees, fruits, grains and vegetables were introduced, although an effort to raise wheat failed because of the climate *Haciendas* quickly developed, commerce, through New Spain, slowly evolved, and simple industry was given a start, the *Adelantado* himself establishing a sugar mill at Champotón, which he held in *encomienda,* and certain colonists introducing indigo culture and experimenting with the production of dyes from the *palo de tinto*

The *encomienda* assumed special importance with respect to the assurance of permanent colonization in an agricultural province such as Yucatan It was the principal means to which the *conquistadores* and colonists could look to secure reward for their efforts and assure their immediate sustenance and maintenance The institution connoted at first service of the *encomendero,* or grantee, by the Indians designated, and the giving of tribute in kind and in products of native

industry. The *encomendero* was under legal obligation to protect the natives assigned to him, further their Christianization, and raise them to a higher level of culture Service took the form of labor on *haciendas* and in such industrial establishments as were developed, burden-bearing and household service, and tributes consisted principally of maize, beans, chickens, turkeys, honey, wax and textiles, the latter in the form of *mantas* The agricultural products gave the *encomendero* and his family their sustenance, and surpluses could be sold or exchanged, and the *mantas* were shipped to New Spain to be sold or exchanged or were employed in barter in Yucatan itself. Service of the *encomendero* was soon eliminated by royal legislation, and tribute, which was originally determined by the *encomendero*, became fixed officially by superior agencies of the royal government Although the *Adelantado* drew up a *tasación*, or taxation of tribute, in the late 1540's, it was not placed in effect, and the first official assessment promulgated was that formulated in the early 1550's by Tomás López, an *oidor* of the *Audiencia* of Guatemala The *repartimientos* of the natives following the final conquest, in view of their importance to the colony, were made with extreme care by Montejo the Younger and Montejo the Nephew It should be pointed out, furthermore, that the number of natives available for assignment in *encomienda* in the period of initial colonization to a considerable extent determined the location and size of towns, as the number of citizens who could be supported in any given town depended on the numbers of the Indians in its district After colonization had become permanent, and upon the elimination of service in its relation to the *encomienda*, the Indians were employed in burden-bearing as free laborers, a practice which led to many abuses and serious political, social and economic problems.

The Christianization of the natives and the establishment of the Church, as basic objectives of the Crown, gave rise to fundamental social and political problems The social and political systems of the Maya were integrally united with the religious, and the destruction of the religion of the Maya also signified the destruction of their political and social forms

In 1519, upon the recommendation of the Crown following the discovery of Yucatan by Hernández de Córdoba, the Pope created the bishopric of Santa María de los Remedios de Yucatán as suffragan of the metropolitan see of Seville Fray Julián Garcés was appointed bishop, but did not assume office, as the lands were not occupied After the conquest of Mexico limits were assigned, and Garcés then occupied the see, fixing its seat at Tlaxcala With the erection of the diocese of Guatemala, Chiapas, hitherto under the jurisdiction of Tlaxcala, was placed within its limits, and in 1538 Chiapas was erected into an independent bishopric, Yucatan and Tabasco being placed within its jurisdiction Juan de Arteaga, appointed first bishop of Chiapas, died before reaching his see, and Las Casas was the first actually to occupy it. The latter thus exercised jurisdiction over Yucatan and Tabasco In this connection, it is of interest to note that, in view of the failure of the *Adelantado* to colonize Yucatan between 1531 and 1535, Arteaga had been authorized to achieve the peaceful reduction of Yucatan, especially in light of the apparent success of the Dominicans in Vera Paz No practical steps in this direction were taken, however Upon the final colonization of Yucatan, the Church soon assumed a definite organization and within a few years the province was erected into an independent bishopric It should be emphasized that the sovereigns exercised great influence over the Castilian Church, and in the Indies, through the grant of the *patronato* by the popes, the Church was so

closely controlled by and allied with the Crown as virtually to constitute an arm of the government The Church hence wielded great political, as well as religious, authority in the New World

The *Adelantado,* in connection with his broader projects, and in accord with the general religious policies of the Crown, had from an early date desired that Yucatan be created into an independent bishopric In 1533 petitions in that sense were placed before the Crown, and it appears that the sovereign proposed to take favorable action After the final conquest similar petitions were sent to the Crown by the Montejos, the municipal governments and the clergy

In accord with his patent, the *Adelantado* in 1527 took with him to Yucatan two members of the regular clergy and one of the secular, the latter, Juan Rodríguez de Caraveo, serving as his chaplain There is little information concerning efforts to Christianize the natives during the east coast *entrada,* however, although Rodríguez de Caraveo may have attempted to carry on such work This cleric accompanied Montejo during the second phase of the conquest and appears to have accomplished a certain amount of work directed toward Christianization He sought appointment as bishop of the see which it was anticipated would be erected During the period of the final conquest and initial colonization a number of secular clergy entered Yucatan, but the extent to which they sought to Christianize the natives is not clear

The indoctrination of the Indians of Yucatan was primarily the work of members of the Franciscan Order Accounts concerning the first arrival of the Franciscans in Yucatan are not conclusive Ecclesiastical accounts relate that after the failure of the *Adelantado* to colonize the peninsula between 1531 and 1535 a group of Franciscans from Mexico established themselves at Champotón and were making rapid progress when a party of soldiers arrived, destroying their work and forcing them to leave the area. These accounts are not verifiable on a documentary basis at the present time, however

The Franciscans permanently established themselves in Yucatan in 1545, and secured exclusive authority for the exercise of the *doctrina* in the province In the year mentioned, one group of four arrived from Guatemala, coming with the approval of the *Adelantado,* and another group of the same number reached the peninsula from Mexico The most outstanding of these, all of whom were of high character and fired with missionary zeal, were Luis de Villalpando and Lorenzo de Bienvenida Montejo the Younger welcomed the friars, cooperated with them in every manner and sought to further their work He convoked the *caciques,* informing them of the purpose of the Franciscans and admonishing them to give heed to their teachings, and gave material aid to the friars in various ways

The friars immediately achieved great success Indeed, this success appears to have been one of the principal causes of the revolt of 1546, which was as much religious as it was political, the native priests fully comprehending that the entire structure of Mayan society, and with it their religious and political influence, was doomed with the permanent establishment of Castilian dominion The revolt temporarily interrupted the work of the Franciscans, but after its suppression they resumed their task with increasing results Some 28,000 natives are said to have been baptized in the area of San Francisco de Campeche alone In 1549 the first provincial chapter was held, and with it the order assumed definite organization in Yucatan Further friars were brought to the province, *conventos* were soon erected at Mérida, Izamal, Conkal and Maní, and schools were established to train the sons of the

caciques Villalpando undertook the study of the Maya language to facilitate indoctrination, and produced a dictionary, a grammar and a catechism Within a short space of time the Franciscans had extended their work throughout the peninsula

The Montejos desired to aid in the establishment of the Church, further the Christianization of the natives, and promote harmonious cooperation between the secular and spiritual arms The *Adelantado* sought the advice of the Franciscans in government, Fray Nicolás de Albalate, especially, becoming his trusted adviser, and Montejo the Younger was commended by contemporary clergy for his attitude toward the Church and the *doctrina* Inevitable controversy occurred, however, between the civil government and the clergy, even before the *Adelantado* was removed from office, and certain of the Franciscans joined in the charges of misgovernment against him which were sent before the Crown Moreover, controversy arose between the secular and regular clergy concerning their respective functions, in which the civil government at times became involved, and quarrels developed between the *encomenderos* and the friars concerning methods of indoctrination and the treatment of the Indians The establishment of the Church and the Christianization of the natives, furthermore, as has already been suggested, struck at the very foundations of the native culture, and through the attempt to destroy the religion of the Indians and replace it with Christianity fundamental religious, social and political problems were created, problems which to-day remain unsolved

In conclusion, it can be stated that the *Adelantado,* Montejo the Younger and Montejo the Nephew, who proved themselves true builders of empire, assume a high place among the conquerors and administrators who won the Indies for the Crown of Castile Basing their activities on the policies and purposes of the Crown, with which they themselves were in full accord, they throughout sought to achieve the permanent colonization of the lands they conquered in name of their sovereign and to lay the foundations for the political and economic development of those lands This they accomplished after prolonged effort and despite many difficult obstacles, and when they were removed from authority they left to the Crown a Yucatan in which Castilian dominion and permanent settlement had been assured, in which the bases of future development had been firmly established, and in which the foundations for the Christianization of the Indians and the full organization of the Church had been well laid

AN APPROACH TO CLASSIFICATION

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TAXONOMY is the science and art of classification applied to organisms Like medicine it exhibits two phases It is an art in the sense that its system finds immediate and practical application as a tool in other areas of scientific inquiry; the practitioners of the art are largely concerned with nomenclature and the system itself regardless of the implications which lie within it It is a science in the sense that it consists of an orderly array of related facts which its practitioners approach in a spirit of inquiry, rejecting dogma Rational and communicable judgments are made from these facts, which, since they deal with the products of evolution, serve to illuminate that process Not all its judgments are rational and communicable, however For taxonomy deals with the forms of organic nature, perception of which is intuitive, that is immediate and without conscious reasoning Its judgments are therefore frequently intuitive and, while they may be capable of formulation, are incapable of demonstration Such judgments depend for their value upon the experience of the investigator with the forms he is investigating and upon his discernment In this respect taxonomy, like other sciences, is closely akin to creative art (as distinguished from that of the artisan as defined above) As time passes and as experience with the subject accumulates, new technics are developed whereby intuitions are confirmed and brought to general acceptance It is important to understand that, as in other domains of scientific inquiry, both rational and intuitional processes are employed and that intuition plays an important and necessary part in the method of taxonomy. It is partly the purpose of this paper to clarify the rôle played by each

It is the essence of classification that the objects to be classified be recognized and arranged according to a plan It shall accordingly be our first step to define the organic entities which we propose to classify, we shall then decide upon the plan for our system of classification and upon the procedure we shall employ to attain this plan. Our goal is an ambitious one and not easily attained

All attempts at the classification of organic nature are completely dominated and conditioned by the discontinuous variation which is its striking attribute. By the very phrase "organic nature" we signify a discontinuous and complex pattern. The living world is in constant reaction with the non-living world, now modifying its surroundings, now being changed by them As a result of this interaction, as we shall see, the pattern of variation is highly discontinuous, not only at any time level, but along the course of time Individuals appear and die. Not only are they discrete from each other, they are discrete from their parents The discontinuities do not cease here, rather, they begin The pattern is such that these individuals are cut off into more or less discrete groups which, by and large, we term species These species may be gathered together into constellations which we call genera, and so on But in the other direction of magnitude, each individual may be resolved into a system of discrete cells and, it would seem, into a system of discrete genes It may be said, therefore, that organic form exists at four levels of or-

ganization genic, which is perhaps molecular, cellular, individual and specific. The elements of each level are approximately of the same order of magnitude, and by their interactions each produces an organic complex at that level It is our purpose to deal with the last of these complexes, the specific; this may be viewed as the ultimate organism in which the components have actual physical contact and continuity

This pattern is an amazing one, the more so since it is subject to constant change It can not be said to have lent itself readily to classification Yet, despite complexity, the living world is not chaotic and unformed, on the contrary, it is coherent, it has orientation and it is capable of a rational and systematic explanation But it is complex, and the fact of this complex and discontinuous pattern requires methods of classification and view-points which are impossible or unnecessary in other realms of science Perhaps we may gain perspective of this pattern if we compare the elements of which it is composed with the elements of classification in physical phenomena

The elements of physics may be said to be four—space, time, mass and energy Although it is true that modern physics deals with problems which involve discreteness in treating these elements, nevertheless the units thus employed are so small that for most purposes the elements of physics may still be approached from the point of view of continuity Each of these elemental concepts therefore implies homogeneity; any variation found within them is therefore continuous. Each concept embraces infinity, the whole can not therefore be grasped. In order that these phenomena may be grasped and studied it is necessary to select units which will be convenient for the purpose at hand. Since nature presents in this aspect a continuous pattern of variation the units chosen are quite frankly quantitative and arbitrary. There is no alternative. It should be borne in mind that a unit is a device for enumeration, and, within any designated context, implies identity of quantities or measures Any unit of measure is identical with any other such unit; a meter here is a meter there In consideration of these facts it is apparent that in physics, as compared with the organic world, the systems to be studied and classified are comparatively simple or may be made so in the sense that the number of variable factors to be dealt with may be controlled for the purpose of experiment The relationships between these variables are simple and of such an order that they may commonly be expressed in simple mathematical equations. The whole procedure is rational save for the initial recognition of the elements

It is conceivable that some such simple methods of classification might be applied to the complex world of organisms Let us, for the sake of illustration, undertake to classify all organisms according to some simple method, as, for example, the number of cells of which each is composed Upon reflection it will be seen that such a procedure would be merely to catalogue all individuals according to a single fact and, if one may hazard a guess, the result would probably be a continuum Under no circumstances could it be said to produce a classification which would reveal or correspond to that pattern of variation which is the most striking attribute of organic nature We therefore reject such methods We accept the existence of a tremendously complex and discontinuous pattern of variation. We undertake to portray these complex variations We agree to search within the organic realm itself for the elements —the species—of which it is composed, which, being found, will permit an analysis of its complexities In this sense our species correspond to the four ele-

ments of the physicist or the somewhat more numerous elements of the chemist It is important to remember that such elements are not units One frequently hears the species spoken of as the fundamental units of taxonomy. They are the elements of taxonomy but not the units, for they are from their very nature non-identical In the organic world the number of such elements is very great Furthermore, from the nature of their origin, they are complex, far more so than the elements of the inorganic world Let us now ascertain by what mental processes we recognize these elements

From the time of Theophrastus and Aristotle, which is to say, from the earliest attempts at a conscious rational organization of the facts of natural history, the recognition of organic elements, the species, has been based upon form, that is, upon morphological resemblances between individuals It is important to note that even in its primitive state this procedure takes into account resemblances, not in single attributes, but in a summation of attributes A shepherd distinguishes his collie from one of the sheep by a modal association of attributes He does not stop to examine dentition or to compare tail-lengths or the quality of the hair He perceives the whole form Only the seven blind men were unable to perceive the whole form of the elephant A child, having once become acquainted with his dog, thereafter recognizes the class despite the diversity of dogs His mind, unknown to him, has summed up the characteristics which go to make up his perception of "dog" His mind has grasped one of the elements of organic form by an intuitive process. We may well forgive him, if at the zoo he confuses dog and coyote, that is due to inadequate experience with the various aspects of *Canis* Our minds, reinforced with far greater experience in this area but still following the same intuitive process, continue thus to recognize the elements of organic form However, it should be noted that our immediate perception on another level has been reinforced by the experiences which we have had, each of which may have been followed by conscious systemization Language is the bridge by which we have passed from the intuited to the analyzed form In this way, given sufficient experience with dogs and coyotes, we are able, when we meet with the fox, even though he be but a single individual, to predict the existence of a new discontinuity, a new element of organic form

It is important to observe that in recognizing the elements of organic form we are recognizing modal associations of morphological attributes Let us understand more clearly what is meant thereby In recognizing the species which we call dog, we recognize that there is an array of individuals in the world which are of a certain form, have hair, walk and run with a motion which presupposes certain correlations of bone and muscle, and so on "Dog" connotes the modal, the ordinary, the usual development and association of these characteristics If we consider hairiness alone a Mexican hairless would not be modal As dogs go it would lie near one extreme of our array of dog hairiness If we consider size alone a St Bernard could not be considered modal, it would lie at one extreme of our range of dog size In this fashion we might resolve our percept of dog into any number of attributes We probably should find that only mongrels could be said to lie near the mode for all these attributes If we wished to obtain a modal likeness of "dog" we might make a composite photograph of several breeds superposed one upon the other Thus might we see our ideal or modal dog Dog, in other words, is the highest common denominator of all previously recognized dogs. In this paragraph we

have for purposes of explanation been consciously analyzing our percept of dog. Let it be clear, however, that it was originally gained largely through intuition, not through rational processes There is apparently no rational way at present to do this Any quantitative approach will still depend upon an intuitive selection of the attributes to be quantized

In the preceding paragraphs we have discussed the methods whereby we recognize certain natural modes of variation which were termed the elements of organic form For purposes of illustration we have used the term "species" as synonymous with such elements, and it is true that these terms usually have the same connotation We believe, however, that species are formed by a gradual process and that at any given time-transect we may find species in the process of becoming In such cases entities may be perceived which are subspecific These subspecific entities are recognized by modal associations of attributes in the same way that the specific modes are recognized At the same time, we delimit them and relate them, as we do species, by rational processes However, it must be borne in mind that while we recognize them as modes of variation, species in nature are actually much more than that They embrace the whole range of associated attributes They might be viewed as constellations of gene-complexes which have been delimited by natural processes Of these constellations some are comparatively diffuse, in the sense that the gene-complexes are equally distributed within the species The variation of such a species might be expressed as a narrow and sharp curve In others the gene-complexes might be thought of as being more localized within the specific population but forming a continuous spectrum The variation of such a species might be expressed as a broad and rounded curve The symmetry of such curves would depend upon the degree to which such complexes were diffused within the population In still others the gene-complexes might be thought of as being localized and, because of barriers, prevented from diffusion In such species the variation might be expressed as a multimodal curve, each mode corresponding to a subspecific entity

Let us assume now that we have recognized not only two of the elements of nature, the dog and the coyote, but many similar ones We have fulfilled our first requirement We come now to the second—arrangement according to a plan; that is, we undertake to relate our elements Contrary to the intuitional procedure of the first phase, our procedure in the second phase is rational It consists first of analysis, second of synthesis

It has been emphasized that our percepts of the organic elements take the form of modal associations of morphological attributes We perceive constellations of physical attributes In order to compare such complex modes it is necessary first to resolve them into at least some of their component parts We inquire now for the first time "What makes this being a dog, what makes this other being a coyote?" Our answer is expressed in an analysis of the attributes which are associated in the mode This analysis may be qualitative or quantitative and is susceptible of both experimental and statistical treatment Because of the complexities which are inherent in biology the development and application of experimental and statistical methods, as well as their codification, has been much slower than in some other branches of science

Having completed such an analysis and having learned to some extent why our minds should have called this creature a dog and that a coyote, we then proceed to compare them and arrange them according to a plan That plan is based upon

phylogeny. By this we mean a causal explanation of the facts of variation.

The day is not long past when it was believed that each species was an act of special creation and relatively immutable The discontinuity of organisms was perceived but not their phylogeny. The reason which was advanced to account for the discontinuities, namely, that of special creation, precluded the possibility of any marked historical changes within the species But with the breaking through of the idea of evolution and upon its final acceptance, it became clear that this discontinuous pattern of the organic world was conditioned by the forces of evolution Thereupon we agreed that our plan of classification should reflect not only the spatial but the temporal and dynamic aspects of the pattern as well In one sense, such a classification would be static It would be like a photograph of a runner in action Yet it is possible to arrange the elements of our classification in such a way that they will reflect in some degree the dynamic processes of their origin A series of photographs projected rapidly upon the screen will produce the illusion of movement. It is this illusion which we seek to attain in systematic botany when we base our system upon phylogeny

Having resolved into their components the associations of characters which constitute an element, our next step is to compare those from each mode which we have reason to believe have the same phylogeny, that is to say, those which have developed from the action of the same gene or genes Such comparisons may be either qualitative or quantitative and are susceptible to experimental and statistical treatment Our experience will suggest that certain characteristics are more significant than others If, of these, a large proportion are similar we postulate a relative closeness of relationship; if only a small proportion, we postulate a distant relationship We assume, and there is good reason for our assumption, that the degree of relationship is generally expressed in the degree of morphological resemblance.

It must be remembered, however, that the idea of morphological resemblance implies dissimilarity as well as similarity. No two organisms are completely dissimilar, nor are they identical. Let us examine the way in which we ordinarily employ this fact We say that we assign species to a given genus or individuals to a given species because of resemblances to other members of that genus or species Yet we say that we distinguish between genera and between species because of dissimilarities This is very confusing, for we have no criterion of morphology for determining how similar or dissimilar any organism must be in any given case of classification

Again, the ideas of similarity and dissimilarity of form are frequently fused into one notion, that of intergradation "To what extent," we say, "do these variants intergrade? If they do not intergrade at all we shall call them species If they intergrade to a certain extent we shall call them varieties of sub-species We shall base our classification upon the degree of intergradation " To approach the subject from this angle is to obscure one of the most striking facts of organic nature the manner in which discontinuity is made manifest, that is, the ways in which these morphological modes come to differ For how is one to arrive at any satisfactory measure of the degree of morphological intergradation? All, or nearly all, flowering plants "intergrade" in the sense that innumerable stages of intermediacy may be found Upon what "characters" shall one fix in order to define his degrees of intergradation? Upon what morphological characters shall one fix in order to define his degrees of di-

vergence? If we rely for interpretation solely upon morphological distinctions, organic nature becomes an apparent continuity—fluctuating, to be sure, but still a continuity—and there seems to be no alternative to the view that any attempts to produce a discontinuity for purposes of convenience must necessarily be arbitrary. Our system under these conditions therefore would approximate to the system of fixed and arbitrary units which is found in physics, with the difference that each investigator would be free to determine his own units of measurement In a word, the causes of morphological intermediacy and intergradation are several and it is possible to have a deep genetic isolation and still have the semblance of intergradation, particularly if we rely upon selected and sometimes preconceived morphological distinctions It is not sufficient for us to inquire "Are intermediate forms present?" Rather must we say "What has been the genesis of these intermediates? What do they mean in terms of evolution?"

We have emphasized the fact that species may be looked upon in one sense as modal associations of physical attributes Let us review some of the factors which bring such species into being, for such information has direct bearing upon our phylogenetic concept in classification and at the same time provides the taxonomist with an important body of facts with which he may interpret resemblances other than in an arbitrary manner

Evolution as we know it in most of the organic world is singularly a product of sexual reproduction limited by external factors. Let us imagine conditions in which there would be unlimited opportunity for sexual reproduction between all organisms at random, that is for a completely effective interchange of genes Given the absence of any selective factors, any mutations which might occur under these conditions would spread rapidly to all parts of the organic universe. Under these conditions, the pattern of variation at any time would be uniform and continuous Even granted any discontinuity due to grouping of allelomorphs, nevertheless, the pattern as we know it would in no sense be realized In such an ideal system all conceivable combinations of genes would occur If we were to ignore the slight discontinuities produced by sharp allelic differences, such a pattern of organic nature might be likened to a pool of water into which droplets of ink might occasionally fall The widening ripple made by each droplet would forecast its ultimate path of diffusion When that diffusion had run its course, the pattern would again be restored.

But the potentialities of sexual reproduction are not only never fully realized, they are realized only in a small degree. Because of the checks and limitations which are imposed by the isolating mechanisms, sexual reproduction and the consequent interchange of genes is highly restricted and localized It is because of the effectiveness of these mechanisms, including the genetic mechanism itself, in isolating and restricting any mutations which occur, that the pattern of nature is so highly diverse We recognize in these localized diversities our specific and subspecific entities Yet highly diverse as this pattern is, only a small proportion of potential diversity is probably realized This is due to two processes, operating upon the basis provided by the genetic mechanism, that of the isolating factors in restricting sexual interchanges as well as that of the mechanisms of selection which, by elimination of forms, produces a modal distribution of specific entities Such modal associations of species we term genera These generic modes are again disposed into larger constellations and so on We might liken the pattern which is formed in this manner to a complex and irregular net, indeed a very

ragged net, in which the meshes vary greatly in size The knots of such a net would be formed of specific, which is to say, segregated individuals The knot might be taken to represent the mode of variation of a species, that is, the usual concomitance of morphological attributes The meshes themselves would represent the variable and unpredictable effects of the mechanisms of isolation and selection The threads would represent the genetic connections between populations, both in the horizontal and vertical planes The reticulate nature of this pattern is especially emphasized and complicated in the flowering plants by reason of the formation of new knots through amphidiploidy

It is clear, therefore, that morphological *resemblances* are due to the fact that through sexual reproduction there is or has been at some time an exchange of genes between the populations Morphological *dissimilarities* on the other hand have come about by the cutting out of complexes of gene combinations from freely breeding populations by the agents of isolation and restriction As systematists we are dealing therefore with *two opposed phenomena and with the results upon morphology of their opposition* To interpret and compare intelligently the morphological attributes of species the systematist must be in a position to evaluate the probable roles played by the agents of isolation

We have seen that two species may arise from one by segregation of a part of the gene complex of the whole, and we have considered the dynamic role played therein by the factors of isolation In this sense we are dealing with evolution at its present level But a phylogenetic system implies evolution at other levels more and more remote in time It embraces two unlike phases of evolution a present one, dynamic and real, and a past one which is conceptual and static, at least as far as classification is concerned. Species have reality They are segregated groups of individuals which affect each other in such a way that they may collectively be termed an organism Species perpetuate themselves, they may even amalgamate through amphidiploidy The genus has no present reality save in a historical sense, nor has any category more comprehensive than the species, save perhaps the coenospecies The genus, as such, can not perpetuate itself nor affect any other genus genetically For purposes of classification a genus is therefore a constellation of similar species If we were to rely solely upon morphological resemblances we should have means for comparison and classification of genera even less certain than we should have in the case of the species For purposes of classification, however, we can delimit our genera upon a somewhat more rational basis if we estimate the probable effect in any particular case of the agents of isolation and particularly of the agents of selection That the agents of selection operate at all levels of the evolutionary gradient seems likely Whether they are equally rigorous at all levels would probably depend upon the plasticity of the organism, that is, the proportion of concealed recessive genes and their potentialities under any given change The agents of isolation, however, begin to operate only at a certain level and produce their most decisive effect within a relatively short period, although they continue to stand on guard, as it were, indefinitely The species are the end products of single strands of the evolutionary pattern, subject now only to the mechanisms of selection, unless, because of some genetic change, they become the initial points of a new strand The interrelationship and the nearness of relationship of the strands is a function of the isolating agents Except when viewed as historical accidents genera

are non-existent, they have the semblance of existence due only to the fact that the agents of selection have not acted at random, but have chosen for preservation complexes of related strands Had it not been for the effects of selection, our net-like pattern would be much less ragged

If this concept of the pattern of organic nature is a true one, then it would seem that the evolutionary doctrine has served to reveal not only the nature of intra-specific variation but also the abrupt change in pattern which exists above the specific level If in classification we rely solely upon morphological distinctions rather than the assumption of phylogeny we thereby deny ourselves the use of a tool which will serve to correlate any particular segment which we wish to systematize, with the more general pattern of nature This fact alone amply justifies the use of phylogeny as a basis for our classification, and we may buttress this fact with the much more important one that such correlations serve to illuminate the course of evolution within the pattern The evidence suggests that this general pattern, in so far as it may be compared to a simple thing, is (in the flowering plants) in the nature of a multi-dimensional net a gigantic and ragged *Hydrodictyon,* floating in time, as irregular and as heterogeneous as it is gigantic, as complex as *Hydrodictyon* is comprehensible in its structure. Moreover, it has orientation, for only that part which floats near the surface has present reality, the remainder exists in the past, or if it exists in the present, exists only as certain attributes within the existent species From present knowledge it would appear that the most direct path of the taxonomist toward an understanding of this phenomenon is that sketched above a recognition of the variational modes and a subsequent undertaking to ascertain the degree of their relationship by means of analysis and subsequent comparison, both qualitative and quantitative, as well as by consideration of the factors which have produced the variants

In the above discussion the author has undertaken to formulate and clarify his approach to problems of classification It is a convention that his name appears as the author The authors are in fact more numerous, for he has discussed different phases of the subject with colleagues and has inevitably assimilated many of their ideas Understanding that the views expressed are not necessarily their views he wishes to make grateful acknowledgment particularly to Edgar Anderson, Theo Dobzhansky, Joseph W Ellis, Joseph Gengerelli, Hugh Miller and Olenus L Sponsler and G L Stebbins

THE LAND IS THE CHIEF

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It is the land that freemen till,
That sober-suited Freedom chose,
The land, where, girt with friends or foes,
A man may speak the thing he will;
A land of settled government,
A land of just and old renown,
Where Freedom slowly broadens down
From precedent to precedent

—*Tennyson*, "You Ask Me Why"

Introduction

In an earlier article a study was made of the systems of land tenure in the Mediterranean Basin, with particular reference to the land problem in Spain and its influence on some of the social, economic and political trends in that country However, it should be pointed out that this problem is not confined to any one political unit or even to one climatic region It has played and is continuing to play, an important role in many widely separated parts of the world There is a proverb of the Negroes of South Africa to the effect that "the land is the chief," and an examination might lead us to the conclusion that it has more than local significance

Ireland

The invasion of Ireland was under way in 1170 when adventurers from England began to take sides in the quarrels of the chieftains of the Irish clans The adventurers soon had the support of the English royalty Under Henry VIII the actual conquest of Ireland was undertaken, and the struggle was carried on with great fury because it became religious as well as political Both the English and the Scotch adopted the method of planting colonists, by which Ulster passed almost entirely into the hands of immigrants from England and Scotland At the end of the wars of the seventeenth century, the holdings of most of the Irish were confiscated by the English, only a sixth of the whole island, and that in the poorest parts, remaining in the hands of the original inhabitants of the country As late as 1903, 750 landlords owned more than half of the island, and three alone had more than 100,000 acres

The consequences for Ireland of this dispossession of the native Irish have been far-reaching Except in Ulster, where landholding Scotch and English settlers cultivated their own farms, the system of vast landed estates was disastrous, because the absentee landlords had no interest in agriculture Conditions in the country became shocking Agriculture was practiced on run-down soils, which were never fertilized, by a steadily increasing and ignorant rural population, always at the mercy of a famine From the beginning of the nineteenth century there was a steady stream of emigration directed mainly towards the United States It increased very much after the great famine of 1846, when the potato crop, the chief subsistence crop of the inhabitants, failed because of a blight

Hence there are very good reasons why Great Britain has had an "Irish question" for several centuries. Concessions had to be made occasionally to prevent armed outbreaks of the peasants A series of laws which were passed from 1869 on enabled many renters to become landowners, with the result that to-day there are six times as many farmers who work their own land in agricultural Ireland as in industrial England, and the system of small landholding tends more

and more to predominate. With it has come a certain degree of economic well-being National aspirations, heightened by religious antipathies and economic inequalities, resulted in the civil strife of 1919–21, and finally in the accord of 1921, which granted Dominion status to Ireland Since that time conditions have improved The interdependence of England and Ireland is recognized more and more by both peoples, farms owned by the operator have increased in number, and rents to absentee English landlords, long a nightmare to the Irish, have been abolished. Local autonomy, with the evolution of a land-owning middle class, has tended toward political stability

The Spaniards in the New World

It should be kept in mind that there were two paramount motives which drove the Spaniards to exploration and conquest in the New World The quest for gold (el dorado) and the desire to add new members to the Roman Catholic Church In the high plateaus of the New World the Spaniards found millions of people living together in great empires in an advanced stage of civilization But the native leaders were ruthlessly set aside and the land on which their subjects lived was portioned out into fiefs, called encomiendas, according less to extension of surface than to size of the population upon it The higher the rank of the chieftain, the larger his estate. A few villages were permitted by royal grant to keep their traditional communal plots (ejidos) But most of the land was concentrated in great landed estates in the hands of a few overlords, and the native inhabitants came under the absolute control of the new white masters Theoretically, this was done so that the Indians would be indoctrinated with Christianity, and the estates were granted by the Crown for only *dos o tres vidas* (two or three generations) But many of these estates remained in the hands of the same family for over four hundred years, and it was usual for the owner, the hacendado, to live as a feudal baron in the great house, the hacienda, in the center of the estate The hacendado was the highest court of appeal to the simple peons living on his land

Mexico

Mexico is a land of distant horizons. The great plateaus of the interior, which are high enough to have a temperate climate and where as a result most of the population is concentrated, are hemmed in by the far horizon of a purple mountain chain Most of the mountains are volcanoes, many extinct, but some of them active from time to time Indeed, the truncated cone of the volcano is a motif which runs through Mexican life—pre-Columbian, as well as modern When one sees the great profusion of volcanic cones it is not at all surprising that such man-made structures as temples and observatories were, even before the arrival of Cortez, modeled after them. But Mexico is not all a volcano-girdled plateau It is built up in layers, or strata the hot lands (*tierra caliente*) around the edges, then the cool or temperate lands (*tierra templada*) and the cold, high mountains (the *tierra fria* or *páramos*) But these are not easily delimited regions. Streams have cut great gashes in the form of canyons into the central plateau so that there is a complex interpenetration of one climatic region by the other The result is that the sharpest contrast in land forms, climate and the cultural landscape are found very close together From one point it is often possible to view areas representative of almost all the major climatic types, from the tropical rainforest to the tundra. from the fertile valley bottoms, where bananas and oranges grow, up through coffee plantations to the dry mesa country, where maguey, maize and barley

grow, and still on as far as the eye can reach through the grazing lands, then the timberlands and finally to the slopes eternally covered with snow In this dovetailing of climatic regions and cultural landscapes lies one of the many attractions of Mexico.

Against this background of sharp physical contrasts there has been an interplay of the many forces—social, cultural, racial, economic—which have gone toward the molding of present-day Mexico During the régime of the dictator, Porfirio Díaz, the industrial policies of modern nations were adopted in Mexico without destroying the feudal structure of the Mexican economic organization Foreign trade increased from $63,000,000 in 1885 to $239,000,000 in 1907, and railway mileage increased from almost nil in the 70's to 16,000 miles in 1911 But this industrialization was paralleled by a rapid increase in the cost of living without a corresponding rise in wages The oil fields and mines were largely foreign-owned, and profits from them left the country

The Hacienda The full flowering of the hacienda system occurred during the Díaz' régime The land of Mexico, the support of the great mass of the population, was in the hands of a very few people Some 60 per cent of the private land in Mexico was owned in estates of 2,500 acres or more, and almost 25 per cent of the privately owned land was in the hands of only 114 proprietors Furthermore, the process of concentration of land in the hands of a few was continuing Villages were deprived of their communal holdings through the encroachment of "colonization" companies, or through the manipulation of water rights by a hacendado Such a landlord might boast blandly of having moved the "mojonera," the boundary post of a village ejido with water rights to a certain stream, which the hacendado thereafter diverted to his own estate Feuds over land often had at the root a feud over water Land was also taken away from "rebellious" villages—particularly Indian villages with good land—by the government, often controlled by the local landlord As a result, the inhabitants of what had once been free villages were gradually forced to become wage laborers on the haciendas, where they were soon tied to the soil by debts and were paid in kind rather than in money in the hacienda store—the infamous *tienda de raya*

Living conditions were very bad on the estates, where often no attention was paid by the landlord even to housing his peons In time the miserable people, who lived like beasts, without the most rudimentary principles of hygiene, became apathetic, morally bankrupt, spiritually insolvent Small wonder that the cry of the landless for "*Tierra y Libertad*" (land and liberty) became with each year more insistent, until at last in 1910 revolution broke out Between 1910 and 1921 there was a nation-wide shift in the population from resident hacienda communities to free villages, the population in the former was reduced from 5,511,284 to 3,913,769 These figures show that the oppressed people fled from their heartless landlords during the period of social and political upheaval in order to return to the free villages where they could till their small plots of land under the age-old system of communal tenure The old landholding aristocracy thus lost some of its power to the village, to agricultural workers and to the newly developed city proletariat

Land Distribution Unfortunately, land distribution has proceeded slowly. In 1930, fifteen years after the inauguration of the agrarian reform, almost seven tenths of the total economically active population engaged in agriculture still belonged to the disinherited landless masses dependent upon day wages or such meager earnings as may be derived from tenant farming or share-cropping Presi-

dent Cárdenas saw that the aims of the Revolution of 1910 had not been completely fulfilled largely because there was no middle class to carry them through Hence, he has speeded up the program of land distribution In the first twenty months of his administration he awarded some 3,000 villages nearly four and one half million hectares (about 10,000,000 acres) of land—over half as much land as had been distributed by all his predecessors together

But most of the *ejidatarios* (those working village communal plots) must have credit long-term credit for relatively permanent types of equipment as well as short-term advances for seed, fertilizers and consumption goods If this credit is not extended by the government the *ejidatario* is at the mercy of the hacendado, loan shark and local politician The problem of *ejido* credit is a problem in education, and progress must be measured not in terms of profits, but in changed attitudes and values, in the growth of initiative, responsibility and the cooperative spirit Educational progress is extremely slow, but even if the rural school—product of the Agrarian Revolution—had failed in all other respects it has kindled hope of better things to come and an enthusiasm for life in hundreds of communities And with education has come greater geographical and social mobility

In conclusion, it may be said with reference to Mexico that the rural villages must be given the land which they occupy and till if economic well-being is to come to them and consequently to the country as a whole, and the benefits of modern civilization must be brought to the Indians without impeding the development and reinvigoration of the native culture It is significant that Cárdenas keeps insisting that he wants to see more Mexicans and fewer Indians In other words, the free Mexico of to-morrow has its roots in the soil, and in the racial and cultural base which was denied for four centuries. In that free Mexico, the hacendado will no longer be able to say contemptuously that "the peon is a machine which runs on pulque" (the native beer, made of the fermented juice of the agave), because, instead of the sodden impotence of peons tied in debt slavery to the hacienda, there will be social and political integration, unity and order

Of course, many foreign investors in Mexico will continue to complain because they are no longer able to realize as much on investments as formerly, and are forced to reinvest a part of their profits in that country Many rapacious politicians will continue to abuse the reforms and become rich men Many pudgy generals will, under the pretext of breaking up great landed estates, themselves become great landlords—still the words of Fray Bartolomé de las Casas, written some 400 years ago, are still applicable (for "King" and "Spaniard," merely substitute "politician," "general" or "investor")

> If the King wishes to have authority over the natural kings of the Indies, and if the Spaniards wish to enter and stay in the Indies, then whatever is done, ordered, and disposed should be for the benefit, not of the King nor of the Spaniards, but for the spiritual and temporal good of the Indians

Puerto Rico

Of the many problems demanding solution in the island of Puerto Rico, that of land use would seem to be the most pressing The history of this island differs from that of Mexico Spain catered to Puerto Rico because it was an outpost, strategically located for protecting and controlling other possessions. From 1810 to 1820, when Spain's South American empire was shrinking, desperate attempts were made to retain the loyalty of the Puerto Ricans In 1815, they were granted a Cédula de Grácias, a special Bill of Rights which was a most amazing document of liberality, incon-

sistent with the general attitude of Spain toward her other colonies. And on February 9, 1898, Spain granted to Puerto Rico la Carta Autonómica, which gave the people practically complete autonomy The principles of this carta were joyously received by the Puerto Ricans, but on October 18, 1898, the island was officially transferred to the United States as the result of a war in the cause of which they had had no part and in which they had had no interest

With this transfer, the island was placed within high tariff regulations Sugar entered the United States free, at an advantage over other competitors In addition to freedom from tariff regulations was the factor of proximity to the greatest sugar-consuming market. American investors were not slow to realize that in Puerto Rico sugar would be king and fortunes were to be made All sorts of intermediaries were used in buying up all land suitable for cane growing At first land was bought at normal or sub-normal prices because many landowners had little faith in the future of the island under American control Soon those who held out were offered twice or many times what the landowner thought the land was actually worth The land-owner sold, feeling sure that the land boom would collapse and then he could buy back the land at his own price—but that time never came The sugar growers have increased their holdings from 61,500 acres in 1898 to 238,000 acres in 1930, and the yield from one half ton per acre to 2 7 tons Large sugar corporations have taken control of the limited areas of fertile flat coastal lands and are reaching out over the valley lands and low hills into the interior They have taken over the areas where formerly subsistence crops were grown Where corn once grew now sugar-cane grows Dark-green cornfields produce "white gold" for investors in a foreign land. Five American sugar companies have most of the best land in Puerto Rico in tracts of 5,000 acres or more The sugar growers have prospered enormously

A statistical study of the island since American occupation may be made to read like a typical American "success" story But, in spite of phenomenal economic progress along certain lines, the welfare of the vast majority of the people has not been improved since the American occupation, if anything, it is worse At one time during the depression nearly 90 per cent. of the people were on the government payroll, mostly in the form of relief This great poverty is largely the result of the scarcity of food crop land Sugar is so profitable that food crops have been crowded back into the hills, grown on unusually steep slopes These tropical hill-slope soils are thin and highly leached, and the yield abnormally low The grower is too poor to buy fertilizer The food-crop acreage to feed one and three-quarters million people is ridiculously small 70,000 acres in corn, 48,000 in yams and sweet potatoes, 41,000 in beans. Not over one acre in ten of the island's 2,176,000 acres is given over to food production, and the poorer land at that. This means that each acre is expected to supply eight or ten people with food. However, the land needed to supply a decent standard of living, according to the United States Department of Agriculture, is some two and one half acres per person On this basis the Puerto Ricans have only one twentieth of the amount needed In cases of this kind food must be imported, but imported food is expensive—much too expensive for the poor Puerto Ricans to buy Thus, the people are confronted with a problem of getting enough to eat They are not inherent revolutionaries, they do not stage Nationalistic demonstrations, kill policemen and shoot at American gover-

nors because lawlessness is "in their blood"—no, they are simply hungry. In the words of ex-Governor Theodore Roosevelt, Jr, the island "seethes with misery", the achievement of even a slight degree of economic security for a bare majority of the people would go a long way toward inducing political and social stability.

To be sure, the problem of land use in Puerto Rico is not the only one clamoring for solution The density of population has increased from 200 per square mile in 1899 to 507 in 1935. The birth rate must be decreased to where it has some relation to the possibilities of making a living But, whatever plans may be brought forward toward the solution of the problems of Puerto Rico, they must include the development of a land-owning middle class with more favorable conditions for the accumulation of local capital

CUBA

Brief mention might be made of Cuba Her cane fields, like those of Puerto Rico, are easily accessible to the neighboring American market, and since her site is so well suited for large-scale, one-crop farming, she has taken full advantage of her position Here, too, most of the good land is largely controlled by sugar companies When Cuba's sugar is in great demand the labor resources of the island are often overtaxed, particularly during the rush season. But the reduced crop which has been raised since the war boom has reduced the demand for seasonal labor In order to avoid great seasonal fluctuations in employment as well as too great dependence upon foreign markets, the country is aiming at greater self-sufficiency. This has meant an emphasis on the growing of food crops on land controlled by sugar companies. Since the owners of these companies are not always sympathetic with present-day trends, the transition period between one-crop farming and a certain degree of self-sufficiency is marked by social unrest, which is reflected by an occasional revolution

JAVA

Conditions in Java contrast markedly with those in Puerto Rico and Cuba On the island of Java sugar cultivation is performed by white planters using native labor and native fields To be sure, the monsoon climate is ideal for sugar-cane and the rich volcanic soil is kept in the best of condition by constant fertilization and by growing sugar in rotation with rice But the really important factor in Java's prosperity is that sugar companies are not allowed to alienate permanently large tracts of land for growing cane. According to Dutch law, the planters may *rent* rice lands for the cultivation of sugar-cane not more than eighteen months in any three-year period This not only insures crop rotation, but it also prevents the island from becoming over-dependent on imports of rice As a result, Java is able to support over 41,000,000 people on 50,554 square miles, one of the densest agricultural populations in the world Wisely administered through Dutch or Dutch-Javanese officials, these people are relatively prosperous and contented, and on the verge neither of starvation nor of revolution.

AFRICA

In many parts of Africa Europeans have favored the plantation system over the native one of local self-sufficiency. Sisal, hemp, cotton, coffee, tea, tobacco, cane sugar, coconuts and bananas are produced on a large scale, almost exclusively for international trade The natives never had a notion of private property in land, in our sense of the term, till they found themselves serfs on huge European-owned plantations, forced to

work many months a year for their new white masters just in order to pay taxes—hut tax, poll tax or some other tax or taxes But a world-wide depression in prices would throw out of work thousands of natives, who had lost the knack of self-sufficiency The post-war depression has possibly had one good effect in that emphasis is being placed on the maintenance of gardens by those employed on the plantations Writers on this subject who have studied conditions at first hand, agree that the majority of the natives on farms or plantations owned by whites have to work harder and live on a poorer diet than did their ancestors

The impact of European industrialization and the plantation system upon the natives detribalizes them, and it brings about a general social disintegration; but the natives receive no new social mores to take the place of the old Elasticity is demanded of Europeans in securing institutions which will work If Bantus want chiefs instead of officials they should be administered through chiefs, properly educated for their work. Racial discrimination embitters the natives At present, for the same crimes widely different sentences are passed on Europeans and natives Hence the native proverb, "the ox is skinned on one side only" is applied to European courts, which it is complained do not mete out even justice

Land Tenure in the Union of South Africa There is an old fable about an Arab and his camel The latter wanted to shelter his head in the Arab's tent, and this desire was granted. But, when the Arab awoke in the morning he found that the camel was entirely inside the tent and that he was outside on the bare sand The fate of the natives of the Union of South Africa resembles in many ways that of the hapless Arab There the proverb that "the land is the chief" is proved only too true. At present 91 per cent of the land is owned by fewer than two million Europeans, whereas only 9 per cent of the land is owned by five million Bantu. The present state of affairs is very succinctly expressed by one Bantu leader. "At first we had the land and the white man had the Bible Now we have the Bible and the white man has the land"

Kenya

In Kenya the average size of estates controlled by white settlers is 600 acres, all of which are good land, whereas the natives own on the average only eight acres, of which at least one quarter is too sterile for cultivation or pasture And in the Nairobi region "squatters" on the great estates which the white people have carved out for themselves are obliged to undertake 180 days of labor each year for the privilege of domicile on land which is theirs by native law The indigenous peoples, forced to work for masters not of their choosing, might sometimes wonder if the "white man's burden" is not somewhat lighter than that which they are called on to bear

Soviet Russia

Under the Czar, ten million tons of grain each year were exported from the Ukraine, which would seem to show that agriculture was prosperous at that time Gradually it is being realized, however, that the Russian grain export was a "fictitious" export A vast peasant population was being exploited by a landlord class that was practically synonymous with the government The exports constituted a sort of prosperous façade behind which large numbers of people were hovering on the verge of starvation.

With the liquidation of the landlord class following the revolution of 1917, peasant holdings increased from fifteen million to twenty-five million in number

and the size of the average holding doubled. Yet there appeared no such surplus of food as had apparently existed before. The reason for this is that the peasants themselves began to eat more wheat and rye, meat and eggs and dairy produce The meat consumption of the average household doubled Ninety per cent. of the grain produce was eaten by the peasants Some of the more tangible results of an adequate food supply were a decline in infant mortality, a decline in the death rate, and an increase of population of from 130,000,000 to 160,000,000 Hence, to-day, since the people have a more adequate diet than formerly, there is not enough food to go around unless the harvest is a good one

It is beyond the scope of this paper to discuss developments in Soviet agriculture since the liquidation of the Kulaks in 1929. Attention is merely drawn to the fact that the Russian peasants in 1917 seized the land in the great landed estates of the absentee landlords and began to grow food for themselves, just as the French peasants did during the French Revolution In both cases the people who in last analysis made the revolution general were peasants, not fire-eating revolutionaries They were oppressed and hungry and simply wanted land on which to grow food

Conclusion

Many more natural regions or political units might be considered—even more exhaustively—but from these few case studies it is clear how universal the problem of land tenure is To be sure, this is not the only problem, as has been pointed out, but it is a very important one A study of the hacienda in Chile, with its millions of rotos (literally "ragged" or "broken" ones), and of the great estates in Argentina and Brazil, etc, to mention only a few other examples—might reveal much the same conditions and trends. And no matter how advanced a civilization or a culture may be, the people who have achieved them must eat, and food in large quantities must be obtained from the land Hence, throughout history land has been an important factor in determining the trend of events. How many people own how much and what kind of land is a matter of vital concern to all Perhaps it is not only in Africa that "the land is the chief"

Whenever there are in any country uncultivated lands and unemployed poor it is clear that the laws of property have been so far extended as to violate natural right. The earth is given as a common stock for men to labor and live on . The small landowners are the most precious part of the State.[1]

[1] Thomas Jefferson, "Writings," Vol 19, p 17

BOOKS ON SCIENCE FOR LAYMEN

THE HEAVENS AGAIN[1]

No other science is ardently pursued by so many amateurs as astronomy There is an amateur astronomical society in nearly every city in the United States Many amateurs have constructed and are constructing their own telescopes in several regions, such as those centering in Chicago, Pittsburgh, Boston and Washington. About 100 telescopes have been constructed by amateurs in the Pittsburgh area alone, and 12 are under construction in Washington at the present time Amateur observers of meteors and other astronomical phenomena are doing much valuable work Most comets are discovered by amateurs The general public is attracted more by a lecture on astronomy than on any other science Astronomy gets an entirely disproportionate amount of attention in the daily press Articles on astronomy are welcomed in the best magazines

Yet astronomy is not taught very generally in colleges and universities The reason is not a dearth of good text-books, for there are many, the book by Skilling and Richardson is the most recent Although it is designed as a text-book, it will be found interesting to the general reader It is a very good book, the line drawings are excellent, the half-tones not quite so abundant as in some other books in the same field, the writing is clear, though not distinguished, and the printing is about all that could be desired

The book excels in its presentation of the principles of optical instruments and methods of making various kinds of observations It is adequate in its presentation of recent chemical, physical and astrophysical theories It falls somewhat short of these high levels in its explanations of dynamical subjects For example, it states that the 433-day variation in the position of the earth's pole is due to a lack of symmetry of the earth about its axis of rotation It states that the Laplacian theory of the origin of the planetary system has been abandoned because of the applications of new dynamical principles, whereas they date back to Newton and were well known by Laplace In attempting an explanation of why the tides raised by the moon in the earth increase the distance of the moon from the earth the authors follow an error apparently first committed by Sir George Darwin in his "Tides" and perpetuated by Jeffreys With such precedents this error is perhaps excusable Fortunately such slips are few

F R M

[1] *Astronomy* By William T Skilling and Robert S Richardson Illustrated vii + 379 pp $3 00 Henry Holt and Company

LIVING DARWINISM[1]

THE book under review is one of the Longmans Living Thoughts Library, the purpose of which is the presentation of "the essence of the great works from every age and nation, distilled and interpreted by kindred thinkers of our day" Except for Darwin the thinkers included in the series are of the literary, philosophical or sociological type, there are separate volumes, for example, on Schopenhauer, Tolstoi, Rousseau and Marx Despite our proneness to exclude scientists from the class of thinkers, it is nevertheless highly appropriate that a natural scientist, Darwin especially, be represented here, for science in general and evolution in particular have profoundly influenced the molding of modern life and thought It is also peculiarly fitting that Professor Huxley should present Darwin's thought to us For aside from his excellent qualifications for this task in his attainments as a biologist, there is added pertinence in his authorship of this

[1] *The Living Thoughts of Darwin* By Julian Huxley, assisted by James Fisher Illustrated 151 pp $1 00 Longmans, Green and Company

volume when we recall that it was his grandfather, Thomas Huxley, who fought so staunchly for the acceptance of Darwinism in the last century

Professor Huxley's volume performs a very useful function For, "while providing a more or less continuous exposition of Darwin's views in Darwin's own words, it provides annotations which in effect translate these views into modern terms " Much has been heard of late from certain quarters about the decline of Darwinism; the theory of natural selection has been especially attacked But the present book dispels such attempts to depreciate Darwin's accomplishments References to recent work in genetics and ecology in the main only serve more firmly to establish the essential correctness of Darwin's original views And where Darwin erred, modern research shows this to be attributable to the biological ignorance of his age The reader of this book will be particularly grateful to Professor Huxley for his clear analysis of the logical structure of Darwin's "Origin" and "Descent of Man," for this analysis does much to lighten the mental labor required to follow Darwin's complex web of inductive and deductive reasoning, and will prevent the formation of the unwarranted conclusion that Darwin is arguing in a circle

Although this volume has been written with the lay reader in mind, the biologist will profit much by studying it Reading the many long quotations from Darwin's books he "can be sure of finding not only unfamiliar and interesting facts among the vast store which Darwin accumulated, but also stimulating ideas which may throw light on his present problems or even suggest new lines of work " This is high praise for work that was done as much as a century ago And this continued pertinence of Darwin's research is the irrefutable proof that his thought is still living science

ALEXANDER SANDOW

THIRTY-THREE EASTERN WILD FLOWERS[1]

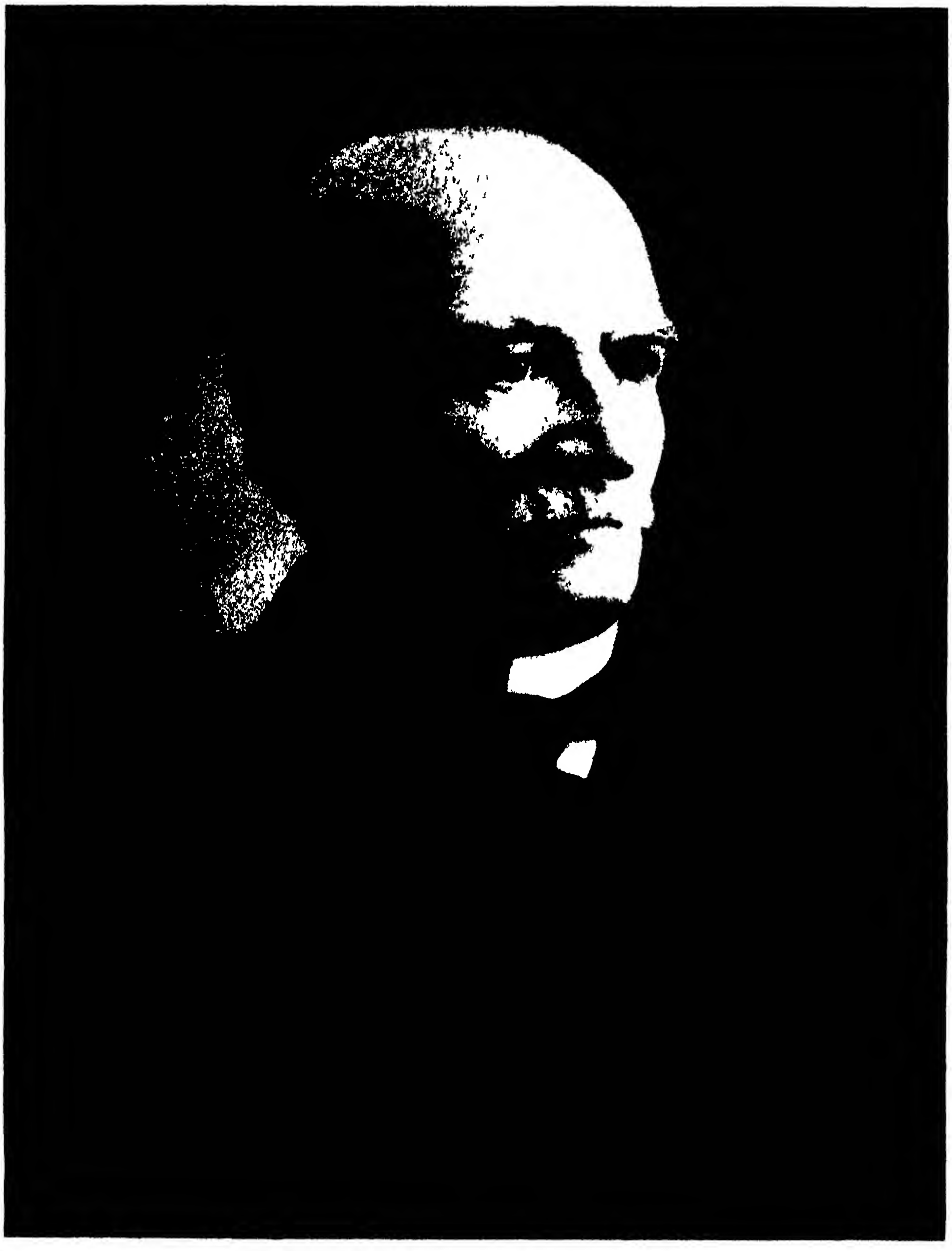
In recent years there has been a tendency, deplorable to a scientist, to give nature books titles which make them appear more comprehensive than they really are The present Book contains brief text and colored illustrations of thirty-three species native to the northeastern United States An effort has been made to arrange these in the order of blooming dates, but there are some discrepancies, as when the yellow ladyslipper, which blooms in early May, is placed in the same seasonal division as the cardinal flower, which appears in August, or the turtlehead, which comes out in September, is listed ahead of the July-blooming milkweed

The descriptive text is attractively written, with cleverly woven-in conservation hints To a person who does not know the plants the illustrations may prove acceptable, but to a botanist they are disappointing The greens of the leaves are either too blue or too yellow, and the faint suggestions of other hues present in various plant parts are overemphasized in many of the plates A layman finding the delicately colored Hepatica in the wild would never be able to identify it from the gaudy red and blue creation here offered On the other hand, some of the paintings are distressingly weak and chlorotic, that representing the fringed gentian utterly failing to bring out the loveliness of this gem of our autumn flowers

A mere scientist who finds it well-nigh impossible to get even a single faithfully colored plate included in a technical work can not fail to wonder how one goes about getting thousands of dollars lavished on the reproduction of mediocre or inaccurately colored paintings by the dozens

EDGAR T. WHERRY

[1] *A Book of Wild Flowers* By M McKenny and E F Johnston Illustrated 80 pp (unnumbered). $2 00 Macmillan Company



WILLIAM WORRALL MAYO, 1819–1911

THE PROGRESS OF SCIENCE

THE MAYOS' CONTRIBUTION TO MEDICAL RESEARCH AND PRACTICE

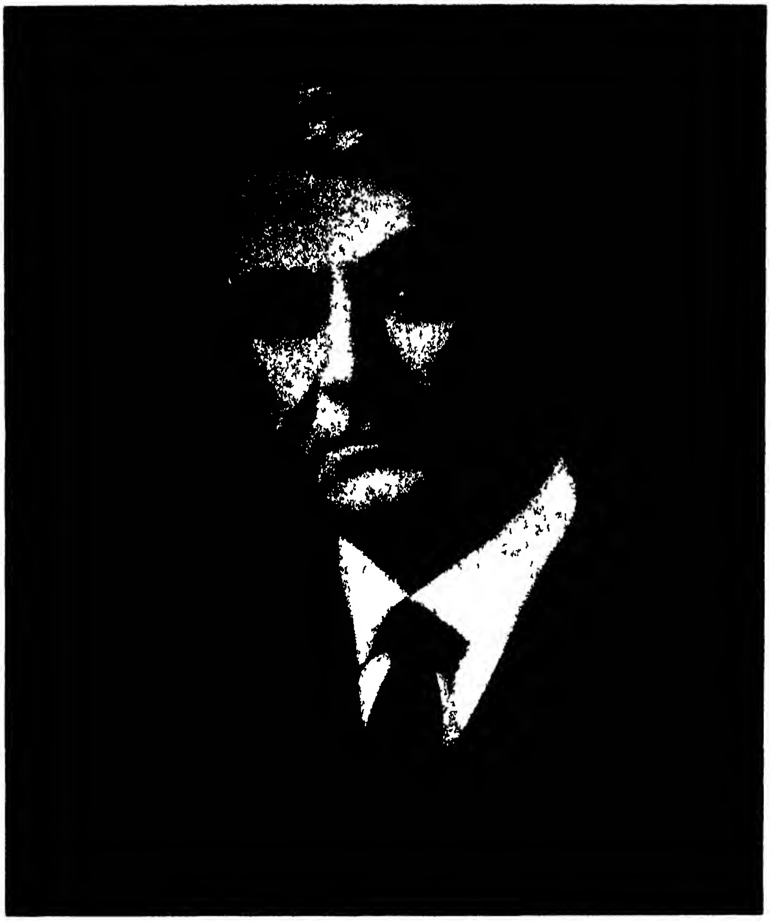
THE medical profession of the world lost two of its most outstanding figures when the death of Charles Horace Mayo, on May 26 of this year, was followed on July 28 by that of his older brother, William James Mayo. Although the deaths of great men occasion proportionately great sorrow, circumstances which attend them sometimes appear peculiarly fitting Thus, it seemed appropriate, if such a word may be used, that these two brothers who had lived in mutual confidence through more than half a century of splendid achievement and who had been acclaimed by the nations, universities and medical organizations of the world for their accomplishments and benefactions, should depart this life almost side by side, as they had lived it.

Readers of THE SCIENTIFIC MONTHLY are acquainted with a number of facts about the two institutions which the Mayo Brothers developed in Rochester, Minnesota, the Mayo Clinic and the Mayo Foundation Many, however, do not know how the Clinic and Foundation happen to be where they are or how the two organizations are distinguished one from the other

Of the two, the Mayo Clinic was the first to take form It was based on a well-organized surgical practice which had been developed by the English-born physician, William Worrall Mayo, and his two sons, William and Charles The name was bestowed, not by the Mayos but by patients and visiting physicians who were attracted to Rochester by the large volume of high-grade work which was being done by the Mayos and their associates In the early days, the Mayos maintained offices such as any physician maintains, and the Mayo Clinic to-day is a doctor's office, merely multiplied many times, and with laboratories for diagnostic work and rooms for treatment of ambulant patients conveniently housed in the same building with the offices Neither the father and his two sons nor the Mayo Clinic ever has owned a sanatorium or a hospital, although several hospitals in Rochester are staffed by physicians of the Clinic

At present the Clinic is housed, for the most part, in two buildings One of these was built in 1912 and now contains laboratories and administrative offices Adjoining this building, in 1927 and 1928 another structure was erected This is now a landmark for many miles around, for it has seventeen stories in use and is topped by a tower which contains a carillon dedicated to the American soldier It is equipped with conveyors and pneumatic tubes for handling records, and furnishes space for approximately 400 physicians and their patients The new building also houses a medical library of 40,000 volumes and the offices of the Mayo Foundation

The Mayo Clinic, as is well known, is engaged in the private practice of medicine and surgery The members of its staff receive salaries; there is no division of profit Its business dealings with patients are tempered by principles which have guided the practice of medicine since Hippocrates Similar humanitarian motives account for the existence in Rochester of the Mayo Foundation for Medical Education and Research, which is part of the Graduate School of the University of Minnesota Concerning this project extracts from a letter written by Dr William J Mayo to the university are significant



WILLIAM JAMES MAYO, 1861–1939

Our father recognized certain definite social obligations He believed that any man who had better opportunity than others, greater strength of mind, body, or character, owed something to those who had not been so provided, that is, that the important thing in life is not to accomplish for one's self alone, but for each to carry his share of collective responsibility

In 1894, having paid for our homes and started a modest life insurance program, we decided upon a plan whereby we could eventually do something worth while for the sick This plan was to put aside from our earnings any sums in excess of what might be called a reasonable return for the work we accomplished

Year by year more young physicians applied for positions as assistants and internes in the hospitals The need of providing in some way a better form of postgraduate medical education for these earnest young men soon became apparent

The fund which we had built up and which had grown far beyond our expectations had come from the sick, and we believed that it ought to return to the sick in the form of advanced medical education, which would develop better trained physicians, and to research to reduce the amount of sickness My brother and I came to the conclusion that this purpose could be best accomplished through the state university

In 1913, when our fund seemed to be of sufficient size to warrant the endowment of a foundation at the University of Minnesota to carry out these purposes, we proposed the affiliation

CHARLES HORACE MAYO, 1865–1939

After careful consideration, the arrangements were agreed upon, June 9, 1915 September 13, 1917, the temporary arrangement became a permanent affiliation, and the results have shown the wisdom of the course pursued

Our relations with the University of Minnesota and its Medical School have been most cordial The graduate students in medicine who have come to the university and through the university to Rochester for graduate medical instruction make a splendid roster Before the Mayo Foundation for Medical Education and Research was established, there had been at the Clinic in Rochester 105 internes, special students, or assistants, 41 of whom are now in university positions The 36 students of this category who were in Rochester at the beginning of the Foundation, became fellows Of the more than 1,350 men and women who have studied on the Mayo Foundation for Medical Education and Research, more than 450 are in responsible teaching positions in medical schools in this country and abroad

The letter from which the foregoing extracts were taken was written in 1934 The numbers of those who have been trained under the Foundation are considerably larger now and the original endowment of $1,500,000 has been increased to $2,800,000 Figures give measures of magnitude, and size is not con-

THE MAYO MEDICAL BUILDINGS

THE NEW CLINIC BUILDING CONTAINING THE EXAMINING ROOMS, THE OFFICES OF THE MAYO FOUNDATION AND THE LIBRARY CONSTRUCTION WAS COMPLETED TEN YEARS AGO THE OLD CLINIC BUILDING AT THE LEFT, BUILT IN 1912, HOUSES THE CLINICAL LABORATORIES, THE REGISTRATION SECTION AND THE ADMINISTRATIVE DEPARTMENT THE MAYO FOUNDATION MUSEUM OF HYGIENE AND MEDICINE AND THE SECTION ON PHYSICAL THERAPY OF THE CLINIC OCCUPY THE BUILDING AT THE RIGHT.

temptible in a thronging world, but it is to the spirit of striving with which the founders imbued their associates that the world is indebted for whatever contributions to medicine and surgery have been made by the Mayo Clinic and the Mayo Foundation

H M R

U. S. GOVERNMENT EXPEDITION TO THE ANTARCTIC

A PROGRAM as extensive as the funds will permit of surveying and scientific research has been planned for the forthcoming expedition to the Antarctic under the recently authorized United States Antarctic Service An appropriation of $350,000 was made available by Congress for this expedition, and Admiral Richard E Byrd, U S N (Ret), has been named its commanding officer The objects of the expedition are to renew the attack upon the unknown sectors of some four million square miles of this southernmost continent, to survey such new lands as are discovered in as much detail as practicable, and to carry on scientific research in many branches of science

The personnel of the expedition will be transported to the south polar regions on three ships the *North Star*, a Depart-

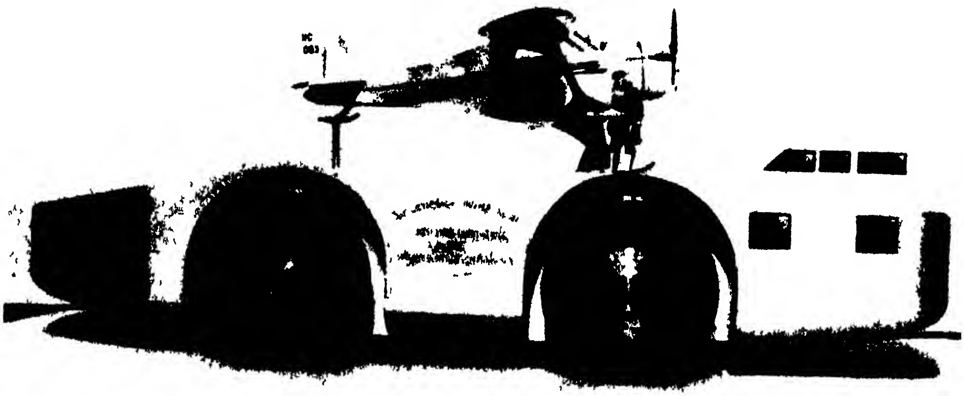
ment of the Interior ship in the Alaskan Indian Service; the *Northland*,[1] a United States Coast Guard cutter that has for years patrolled the Alaskan waters, and the *Bear of Oakland*, Admiral Byrd's barkentine, veteran of many attacks upon both polar regions

It is proposed to erect two main base camps, the exact locations of which will not be definitely decided until the wintering parties have studied the local conditions and weighed carefully the many factors to be considered One base will probably be located at or within a hundred miles or so of Little America and the other in that sector south of South America There will be twenty-two to twenty-five men stationed at each of these bases and four additional men will man the snow cruiser, a mobile base There will be approximately ninety sledge dogs at each base and at least one airplane for aerial survey work It was proven during the Byrd Antarctic Expedition II, 1933–35, that tractors could be successfully used in many localities of the Antarctic and, profiting by this experience, Admiral Byrd will station at each base at least one track-laying type of machine for the heavy transport work

The various scientific branches of our government and many leading scientific institutions and foundations are cooperating to assure the success of the program On July 28, there was held at the National Academy of Sciences a meeting of thirty men, many of whom are leaders in their respective fields, called by the National Research Council at the request of Admiral Byrd and the Executive Com-

[1] It has just been announced that the *Northland* has been withdrawn by the United States Government for patrol duty, a situation brought about by activities in connection with the enforcement of the Neutrality Act

BEAR OF OAKLAND, ADMIRAL BYRD'S BARKENTINE



THE ANTARCTIC SNOW CRUISER

DESIGNED BY THE STAFF OF THE RESEARCH FOUNDATION OF ARMOUR INSTITUTE OF TECHNOLOGY UNDER THE DIRECTION OF DR THOMAS C POULTER, SCIENTIFIC DIRECTOR THE CRUISER, WHICH WILL CARRY A FIVE-PASSENGER SPEEDY AIRPLANE ON ITS BACK, HAS AN OVERALL LENGTH OF FIFTY-FIVE FEET AND STANDS FIFTEEN HIGH ON TEN FOOT RUBBER TIRES, IS FIFTEEN FEET WIDE, ACCOMMODATES FOUR PEOPLE WITH SUPPLIES AND FUEL FOR ONE YEAR, HAS A CRUISING RANGE OF ABOUT FIVE THOUSAND MILES THE COST OF THIS "WHEELED DINOSAUR" WILL BE ABOUT $150,000

mittee of the Antarctic Service Dr Isaiah Bowman, president of the Johns Hopkins University and past director of the American Geographical Society, presided at the meeting The scientific program was discussed in detail and suggestions were made for its enlargement and improvement An Interim Committee on Scientific Work of the United States Antarctic Expedition has been appointed by the National Research Council It consists of the following men Dr Isaiah Bowman, *chairman;* Dr Henry B Bigelow, director of the Woods Hole Oceanographic Institution, Dr John A Fleming, director of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, Dr W C Mendenhall, director of the U S Geological Survey, Dr Robert Cushman Murphy, curator of oceanic birds, American Museum of Natural History, Dr C G Rossby, assistant chief of the U S Weather Bureau

The program itself is quite varied and will require a trained personnel of twelve scientists, who will be assisted by other members of the expedition in their activities

Two meteorological observatories will be established for routine observations, including pilot balloon runs at regular intervals Radio-sound equipment for upper-air observations will be put into use at one base on an experimental basis Data will be exchanged with the Argentine station on Laurie Island and with other countries that are proposing to establish meteorological stations in the Antarctic this year

Many important problems connected with the aurora are unsolved, and any data on this phenomenon may be of value in solving some of these problems There will be hourly observations during periods of darkness to determine times of beginning, ending, significant changes, color, intensity, form and variation in position and height in the sky with magnetic or geographic latitude The displays will be photographed

It is proposed to investigate further the changes in cosmic-ray intensity at points of high geomagnetic latitude and

to determine causes of fluctuation An apparatus which will record continuously the cosmic-ray intensities will be set up at one base.

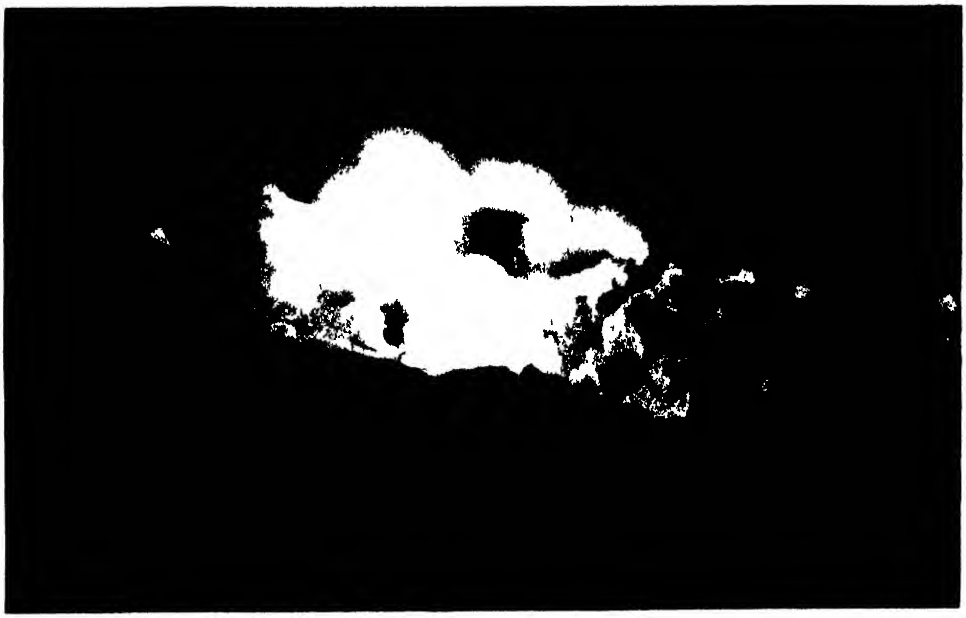
Geology has a prominent position in the program There will be made detailed investigations of the structure, stratigraphy and compositions of all mountains and rock exposures visited The principal topographic features will be mapped, and in detail when and if possible An attempt will be made to learn the relationship existing between the various structural provinces of the Antarctic All outcroppings visited will be examined for possible mineral resources Characteristic specimens of rocks, minerals and fossils will be collected for later detailed study and identification

The program of Ice Studies has been very carefully planned and it is expected that many facts of interest to glaciologists will be brought to light The British Association for the Study of Snow and Ice has fully cooperated in planning this program The members of that association have been most helpful in suggesting problems to be investigated and the procedures to be followed in carrying them out Sincere thanks are due these men The glaciological program will be undoubtedly the most comprehensive so far attempted in the Antarctic

Two ice laboratories will be maintained, one at the Western Base (vicinity of Little America), and the other, it is hoped, at the Pole If this is not possible, the station will probably be established on one of the ice plateaus The former station will be occupied continuously for a year, the latter for a period of three months during the winter In addition to the comprehensive series of

PROTECTION FROM THE ANTARCTIC WINDS.

A GROUP OF EXPLORERS ON THE SECOND BYRD ANTARCTIC EXPEDITION FROM LEFT TO RIGHT DR PAUL SIPLE, WHO WILL DIRECT A PROGRAM ON THE HUMAN ADAPTATIONS IN THE ANTARCTIC, OLIN SANCLIFF, DR F ALTON WADE, SENIOR FIELD SCIENTIST ON THE FORTHCOMING EXPEDITION, AND STEVENSON COREY



PRESSURE ICE NEAR LITTLE AMERICA IN THE LIGHT OF MAGNESIUM FLARES

observations at these stations, certain others will be made at the Eastern Base, at all sub-bases and by members of all trail parties in the localities which they will visit

The program will include: (*a*) "Ice" thickness measurements; (*b*) determinations of densities of the glacial "ice", (*c*) study of the variations in grain size and shape with depth; (*d*) crystallographic studies of the snow, firn and ice, (*e*) temperature measurements, (*f*) measurements of velocity of flow of various kinds of ice formations; (*g*) studies to determine the mechanism of glacier flow; (*h*) measurements of the annual accumulation of snow, (*i*) measurements of the loss due to ablation, (*j*) investigations to determine the origin of banding in the ice

Methods of reflective seismic prospecting will be used to determine the thickness of the ice at regularly spaced intervals along as many traverses as possible, and thus roughly determine the rock surface profile beneath the ice along these lines By using this method it will be possible to determine whether or not a strait exists that connects the Weddell and Ross Seas The same soundings may also yield information concerning the underlying strata A reconnaissance gravity survey is contemplated, using a portable gravimeter This survey will be made in connection with the seismic survey so as to have accurate checks on ice thicknesses at stations occupied At a mainland base a seismograph will be erected to record earth tremors Such information would be invaluable in locating the epicenters of earthquakes in the South Atlantic, South Pacific and Indian Oceans

Continuous observations of the declination, inclination and total intensity of the earth's magnetic field will be made at one main base Additional observations will be made by parties in the field and at sub-bases

Four biologists will accompany the expedition One will be stationed at each base and the other two will remain at the ships Specimens will be collected of all forms of plant and animal life found

near the bases, on trail journeys and from the ships for critical study and deposition in the National Museum Live animal specimens will be brought back to the National Zoological Gardens. Life history and behavior studies will be made of the animals when possible.

A comprehensive oceanographic program is contemplated The ship assigned to this work would occupy a station at intervals of forty miles along a north-south line from fifty-five degrees south latitude to a point as far south as possible

An investigation of the prolonged Antarctic conditions upon the metabolism of the parties by recording daily blood pressures, pulse rate, rate of breathing and strength as measured perhaps by an ergograph will be made Such records would be useful not only for comparison with similar records at home, but as a means of determining the effect of changing conditions in Antarctic environments

Many geographical problems will be attacked Dr Paul A Siple, veteran of two Byrd Antarctic expeditions, will direct an interesting program in this field, placing special emphasis on the human adaptations and relationships to the climatic conditions of Antarctica

The mobile units of the expedition will be watched with keen interest No means of transportation thus far tried in the polar regions has been entirely satisfactory Dogs are the most reliable, but are slow and can not haul sufficient equipment Airplanes can be operated successfully, but good flying weather is rare and surface operations from the planes are rather hazardous Tractors have been operated successfully but with difficulty, and crevassed regions have never been successfully negotiated by them As a research project, the Research Foundation of the Armour Institute of Technology has designed, under the guidance of its director, Dr Thomas C Poulter, who was senior scientist and second in command of the Byrd Antarctic Expedition II, a snow cruiser that should prove to be the answer to the prayers of polar explorers It will be in reality a mobile base Fifty-five feet long and traveling on wheels whose tires measure ten feet in diameter, it has a cruising range of five thousand miles, a cruising speed of twelve miles per hour, a top speed of twenty-five and carries a plane with a cruising range of fifteen hundred miles on its top deck The quarters for the crew of four men are comfortable and spacious It has a control cabin, engine room and machine shop, galley and laboratory and carries supplies for a year The scientific equipment includes a reflection type seismic sounding outfit, a gravimeter, dip circle for magnetic measurements, apparatus for ice studies and instruments for both ground and aerial survey work.

F Alton Wade,
Senior Field Scientist
The U S Antarctic Service

SEVENTH CONFERENCE ON SPECTROSCOPY AND ITS APPLICATIONS AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Two hundred and fifty scientific men from the fields of physics, chemistry, biology, medicine and metallurgy gathered for a three-day session in July in the George Eastman Laboratories of the Massachusetts Institute of Technology to hear a series of papers concerning the uses of the spectrograph in their respective sciences Coming from as far away as Germany and England and from all parts of the United States and Canada, workers in different fields found themselves drawn together by an interest in a tool which has come to be of great importance, as a result of its ability to probe matter and analyze light

The spectrograph has for many years been recognized as the most powerful instrument available for qualitative analysis of materials, since with a single photo-

graphic exposure it reveals the presence or absence of seventy of the chemical elements It has been increasingly recognized that spectrographic methods can also be made very useful for quantitative determination of the atomic constituents of any mixture of substances no matter how complicated, particularly when the chief concern is with the metallic atoms present Gradually the precision attainable has been improved, until recent papers have reported precisions of ± 3 per cent of the amount of material present, a precision truly remarkable when it is realized that it often remains constant down to concentrations as low as one part in ten million or less

At the Seventh Spectroscopy Conference workers from several laboratories reported improvements in this precision Routine results reported from the University of Michigan were found self-consistent and accurate to within ± 1 25 per cent This exceeds the precision of chemical wet determinations, and several speakers at the conference reported complete supplanting of ordinary wet methods by spectrographic methods whenever determination of metallic constituents was involved Wet methods are still used, of course, for the determination of negative radicals and for handling molecules, unless this can be done by the methods of absorption spectrophotometry

The first day's session of the conference was opened by a paper by Dr W F Meggers on "A Quarter Century of Spectrochemical Analysis at the National Bureau of Standards" Dr Meggers traced the improvement in spectroscopic methods of analysis from their first use at the bureau, and pointed out that thousands of analyses for other government departments are now made annually at the bureau using spectrographic methods Other papers at the first session recounted applications of spectrographic methods to problems of the ceramics industry, of the telephone industry, of the optical industry and in the preparation of war materials

Motion pictures of a new spectrographic installation at the Ford Motor Company were shown by H B Vincent, of the University of Michigan In the Ford laboratories large numbers of analyses are carried out at high speed, the samples being sent from the foundry by pneumatic tube to the Spectrographic Laboratory and results being made available within a few minutes after receipt of the samples Similar methods are now used in several large foundries, and the workers responsible for their installation reported complete satisfaction with the spectrographic method

A series of papers was presented on new spectrographic apparatus, particularly on new microphotometers for use in quantitative spectrographic analysis Two papers were concerned with the increasing trend toward use of diffraction grating spectrographs instead of prism spectrographs The diffraction grating is recognized as having numerous advantages over the prism, but the limited number of gratings which can be obtained has delayed its use Several manufacturers reported increasing demand for diffraction grating spectrographs, and the number preparing to provide such instruments is growing

Another group of papers reported on the applications of spectroscopy to medicine, principally in the field of absorption spectrophotometry Hormones, vitamins and various other complicated materials can be determined quantitatively with ease by sending light through a solution and studying the absorption of this light with a spectrograph The spectrograph method is now recognized as standard for analyzing for vitamin A in cod liver oils and other materials, since it is rapid, precise, and does not destroy the material being analyzed

Among the most important papers presented at the conference were a series on the sources of light used in spectro-

graphic analysis In order to determine what kinds of atoms are present and to what extent in a given sample of material, it is necessary to burn the material in an electric arc or spark or in some similar source in order to excite the atoms to emit light Some of the errors made in analyses have been traced to variation in these light sources, and improvement in their control is found to go far toward improving the consistency of the results obtained, it was reported at the conference Dr H Kaiser, of the Zeiss Works in Jena, Germany, reported on studies of light sources which had been made in his laboratory, which showed that such improvements allowed quantitative results to be obtained which were in error by not more than 1 5 per cent of the amount of material present

The full attendance at the conference, which taxed seating facilities, testified to continued wide current interest in spectroscopy and its applications Tentative plans are being made for an eighth spectroscopy conference in the summer of 1940

George R Harrison,
Director of Applied Physics
Massachusetts Institute of Technology

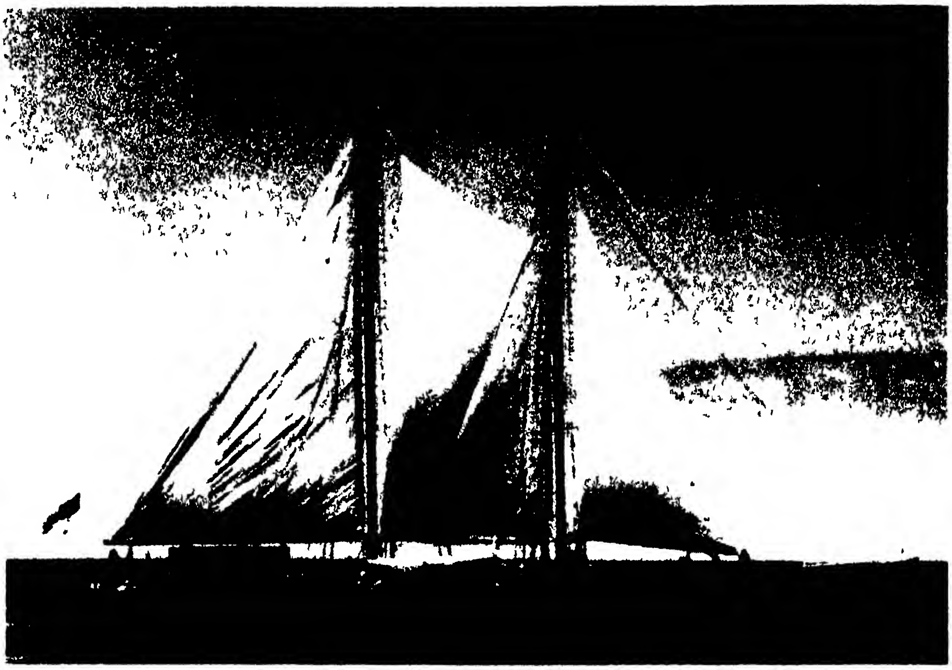
CRUISES OF THE E W SCRIPPS IN 1939

In July the research vessel, *E W Scripps*, of the Scripps Institution of Oceanography, completed a cruise in the Pacific Ocean off the United States coast It was undertaken with the cooperation of the U S Bureau of Fisheries to study the dynamics and ecology of the Pacific Ocean Earlier in the year the vessel made a cruise to conduct studies in the Gulf of California

The *E W Scripps* has been in commission for a year and a half and has proved very suitable for general oceanographic work The main dimensions of the vessel are length overall 104 feet, length of water line 93 7 feet, beam 21 1 feet, draft 12 feet, gross tonnage 108, net tonnage 59 Built in 1924 as a wooden auxiliary top-masted schooner for ocean racing and extended cruising, she changed ownership several times and was subjected to alterations including replacement in 1929 of the original engine by a Winton Diesel engine rated at 175 h p and giving a cruising speed of 8 or 9 knots under power

After the vessel had been bought in April, 1937, by the late Robert P Scripps, to be donated to the Scripps Institution, a considerable number of changes were made in order to adapt the vessel for oceanographic research The sail area was reduced by removing the top-masts, shortening and lifting the main boom, changing the main-sail from a gaff sail to a Marconi sail and raising the boom of the foresail A deck-house was built aft with a small pilot in the forward part and in the after part a deck laboratory was constructed which communicates directly with the laboratories below deck through an open hatchway On deck two winches were mounted, one large winch aft of the foremast, carrying 20,000 feet of ¾ inch wire rope for deep-sea anchoring and dredging, and one smaller winch carrying 5/32 inch wire rope for hydrographic use Both winches are operated by electro-motors, the power being supplied by means of a 21 h p Superior Diesel motor in the engine room Below decks one large and two small rooms on the starboard side were remodeled for use as laboratories, and on the portside three staterooms with six berths for members of scientific parties were provided In the crew's quarters ten berths are available, but on most cruises the permanent crew has numbered five or six

After the *E W Scripps* in 1938 had worked exclusively in a small area off the coast of southern California two extended cruises were made in the first half of



THE RESEARCH VESSEL OF THE SCRIPPS INSTITUTION OF OCEANOGRAPHY
THE E W SCRIPPS, OFF LA JOLLA ON MAY 10, 1939

1939, one to the Gulf of California and one off the west coast of America

The cruise to the Gulf of California took place between February 5 and March 31, the work in the Gulf being conducted between February 13 and March 19 Mr E G Moberg was in charge of the cruise until the author joined the vessel in Guaymas, Mexico, on March 8 Other members in the party were Messrs Fleming, Johnson, Revelle from the Scripps Institution and Messrs Loye Miller and Harry Allen from the University of California at Los Angeles The Gulf was crossed and recrossed a number of times and on each crossing oceanographic stations were occupied at which temperatures of the water were determined at a series of depths between the surface and the bottom, water samples for chemical analyses were collected from these depths, samples of phytoplankton were taken at seven depths between the surface and 60 meters, vertical hauls for zooplankton were made and samples of bottom sediments were obtained A total of 53 stations were worked and, in addition, soundings by sonic depth finder were made for nearly every mile during the entire cruise in the Gulf

It was found that the bottom of the Gulf is much more irregular than indicated by the few soundings which were available prior to the cruise The greatest depth along the most southern line is more than 10,000 feet, but traveling north the depth shows a general decrease, although it is probable that several longitudinal and transversal ridges exist From Tiburon Island a ridge appears to cross the Gulf in a nearly southerly direction, the greatest depth along the ridge being about 750 feet. To the northwest of this ridge a deep trench is found between the island Angel de la Guardia and the smaller islands to the south on one side and the peninsula on the other side, the maximum depth in this trench

being about 5,000 feet. Here basin condition exists with temperature near the bottom close to 11° C, whereas at corresponding depths in the outer portion of the Gulf the temperature is about 4° C The most northern station was occupied only forty miles from the mouth of the Colorado River, but the salinity of the water at this station, 35 12° parts per thousand was only slightly lower than the maximum salinity found a little further south, 35 50° parts per thousand

The deep water in the outer portion of the Gulf is of the type which is found in the eastern central Pacific and is characterized by a salinity minimum of nearly 34 50° parts per thousand at a temperature of about 5° C and by practically no dissolved oxygen between depths of 150 and 800 meters

During the cruise strong northwesterly winds blew intermittently, giving rise to upwelling in various localities along the mainland side of the Gulf, and in the inner portion winter cooling and excessive evaporation produce vertical convection currents reaching to considerable depths These processes probably account for the great abundance of plankton which was encountered in many localities It is of interest to observe that in the inner portion of the Gulf large numbers were found of the dinoflagellate *Gonyaulax*, to which the mussel poisoning on the coast of California has been ascribed, and that some time after the cruise several cases of mussel poisoning were reported from that very region

The second cruise of 1939, between May 10 and July 12, was conducted in cooperation with the Federal Bureau of Fisheries The purpose of the Scripps Institution of Oceanography was to make a general survey off the coast of the character of the water masses and currents and of the plankton distribution in early summer, while the purpose of the Bureau of Fisheries was to examine the occurrence and distribution of sardine eggs and larvae The plan called for 106 oceanographic stations, most of which should be located along eight lines at right angles to the coast between latitude 45° N and 25° N, each line extending to a distance of 200 to 350 miles from the coast Bad weather made work on two of the lines impossible, but in spite of storms 90 of the planned stations were occupied Examination of the data has not yet been completed, but the observations confirm conclusions as to the character of the currents off southern California, based on cruises in 1937 and 1938, and furthermore indicate that in general the distribution of surface temperature shows a tongue-like pattern, tongues of cold water alternating with tongues of warmer water Such a pattern has been shown to exist off the coast of Peru and may be a more general phenomenon than hitherto recognized, probably because closely spaced stations are needed to reveal this feature which is typical near the coast only

At the present time the *E W Scripps* is laid up in the harbor of the San Diego Yacht Club, but in the spring of 1940 it is planned to continue the detailed study of conditions in the area off southern California

H U SVERDRUP,
Director

SCRIPPS INSTITUTION
OF OCEANOGRAPHY

SOME FACTORS INVOLVED IN THE INVASION OF THE BODY BY THE VIRUS OF INFANTILE PARALYSIS

POLIOMYELITIS is now generally conceded to be a virus disease affecting principally the nervous system In man the most striking evidence of its activity is the muscular paralysis which results from the destruction of the large motor nerve cells of the spinal cord, but there is also considerable damage to other types of nerve cells whose loss is not so readily appreciated Attempts at the treatment

of acute poliomyelitis have thus far been largely futile because so little is known of the growth habits of the virus that a basic rationale has been lacking. For example, there is still great controversy regarding the portal by which the virus of poliomyelitis enters the nervous system of man.

With so little exact data obtainable from man, it is natural that investigators have turned to the experimental animal. Ordinary laboratory mammals are immune to the disease, so it has been necessary to use the monkey, which does not spontaneously contract poliomyelitis, but which may be successfully infected. When large amounts of active virus are introduced into the nose of a monkey, it succumbs to a paralysis closely resembling human poliomyelitis. When the nerves of smell have been cut previous to inoculation, the animal remains well. It therefore seems evident that, in the monkey, virus reaches the brain along certain nerves, of which the olfactory nerves appear to be the most important. This finding has given rise to the widespread belief that human beings are infected along a similar route. As a matter of fact it indicates but one thing—that the olfactory route is the route of choice in the monkey; as yet there is no definitive evidence pointing to this portal of entry in man and indeed considerable reason for the belief that the more susceptible human may be invaded at more points than the experimental animal. How then may one begin to collect evidence which will bear upon such a contention?

Polio virus not only reaches the brain and spinal cord through nerves, but continues to travel along their projections within the central gray matter. In other words, the virus progresses within the central nervous system along nerve pathways which are connected with the ones by which it entered. In doing so it registers its presence by a train of inflammation which is microscopically visible. Because of the extensive invasion of myriad connections within the brain, the picture of the disease as it appears in individuals dying of poliomyelitis has thus far been too complicated to allow interpretations regarding the route by which the infective agent gained entrance.

It is to the experimental animal that one turns in an impasse of this sort. Although possibly differing from man in its range of susceptibilities, it nevertheless should reveal certain general rules for virus behavior which may be applied to the riddle encountered in human material. Accordingly monkeys have been infected by a wide variety of portals of entry. These include not only inoculations into the nose and skin (which also is a low resistance portal in the monkey), but in addition such highly artificial sites as the eye and various parts of the brain itself. The resulting picture of inflammation in the brain and spinal cord has been studied in great detail. In the early stages of the disease it is a relatively simple matter to deduce the portal of entry from a microscopic examination of the brain. As in man, by the time the disease has become fatal, the picture is very complex. This is due to the fact that, whatever the route by which the virus has reached the brain, it eventually invades the great motor systems. Thus the final stages of invasion all tend to look alike—but there are differences, important differences, still reminiscent of those simpler early pictures, which make it possible to thread through the maze. Such studies furnish general principles which may lead to an understanding of the experiment of nature upon man.

Howard A. Howe
David Bodian
The Johns Hopkins University
School of Medicine

THE SCIENTIFIC MONTHLY

NOVEMBER, 1939

RECENT PROGRESS IN PLANT BREEDING

By E. B. BABCOCK

PROFESSOR OF GENETICS, UNIVERSITY OF CALIFORNIA

THE utter futility of attempting to present the accomplishments of breeders of the various agricultural and horticultural crop plants in one short paper must be obvious, at least to those who are familiar with the wide scope of plant breeding activity in nearly all countries For this reason an attempt will be made to review some aspects of recent progress in plant breeding in such a way as to indicate promising lines of future progress If, in so doing, the layman is disappointed by the paucity of startling achievements, it is hoped that the plant breeder will be encouraged and stimulated by the interesting possibilities which are being opened up by recent research in genetics, cytogenetics and plant physiology.

In 1922 Edward M East[1] published a brief but penetrating review of the progress in genetics since 1900. He did not touch on applied genetics, but gave an excellent summary in terms of general conclusions regarding the laws of heredity, the mechanism of heredity and the bearing of genetics on evolution. Let us now consider the status of plant breeding at about the same time by briefly mentioning a few events and publications which may serve as guides in our effort to evaluate the progress that has been made during the past decade or two To save time, I shall look backward at only three phases of plant breeding; but, as a matter of fact, the recent progress in these fields involves the application of the most advanced theoretical genetics and cytogenetics These three phases may be designated as breeding plants to order, utilizing hybrid vigor and breeding for disease resistance

In 1921 East and Jones[2] published a paper on round tip tobacco—a plant "made to order," illustrating the application of genetic principles to produce a new type of crop plant to meet the grower's demand by the crossing of existing varieties of a single species This of course was not the first achievement of this sort The creation of new varieties by combining in hybrids the desirable characteristics from two different parents had been accomplished even before the rediscovery of Mendel's laws in 1900 But those earlier plant breeders, including some who were prominent in the early years of the present century, and even some who are engaged in empirical plant breeding at present, were working more or less blindly and often without any appreciation of the importance of carrying on to the second generation after crossing two varieties By the

[1] E. M. East, *Jour. Heredity*, 13: 207–214, 1922.

[2] E M East and D. F. Jones, *Jour. Heredity*, 12 51–56, 1921.

end of the second decade of the present century most scientifically trained plant breeders were well aware of the practical value of applying the Mendelian principles in the work of plant improvement by means of hybridization And now, as we near the end of the fourth decade, one can hardly find a single important crop plant or ornamental flower that has not been improved in productivity or quality, at least in some country or countries, by systems of breeding based on the Mendelian principles The breeding of plants to order will be further illustrated in connection with the breeding of disease-resistant plants

In 1919 East and Jones[3] published their monograph on "Inbreeding and Outbreeding," in which they called attention to the probable future importance of heterosis or hybrid vigor in crop production They emphasized the great potential value of the so-called double-crossed corn in increasing the yield and uniformity of maize, the most important field crop in this country As early as 1910 G H Shull and East had independently applied Johannsen's pure line concept to maize, which is naturally cross-fertilized, and after demonstrating the extremely deleterious effects of inbreeding on self-fertilized lines of maize, they had discovered that crossing certain of these inbred lines would produce first generation hybrids with high yield and a much more uniform crop than the original unselected variety Soon it was discovered that some of these first generation hybrids are more resistant to diseases and pests than the original varieties Then Jones began to experiment with secondary crosses between various first generation hybrids, with the idea that in some such crosses there should be still further increase in vigor and yield The result was his recommendation that double-crossed corn, produced by crossing carefully selected first generation hybrids between inbred lines, should be used in producing the future supply of seed corn.

It required another decade or so of experimentation and demonstration to convince some of the leading corn breeders and corn seed growers that properly produced double-crossed seed is the best from most points of view The testing of many different inbred strains as parents of first generation hybrids and the testing of these single-cross hybrids in various combinations to produce the best double-cross hybrids is still going on and no doubt will continue indefinitely at least in certain experiment stations But it is now fairly safe to predict that double-crossed hybrid seed will soon be used for the bulk of the nation's corn crop According to Jungenheimer,[4]

> comparisons in many states indicate that *certain* corn hybrids are more able to withstand drouth, wind, diseases, insects and other unfavorable conditions than the best standard varieties These qualities reduce the hazards of corn production, with resultant benefits to the grower and consumer . The first commercial hybrid seed corn was produced in Connecticut about 17 years ago Corn belt hybrids adapted to the corn belt have been available for only about 10 years, but during that time their use has shown a phenomenal increase In fact the acreage of hybrid corn has doubled and trebled every year during the past three or four years Almost unknown to the average corn grower four years ago, about 17,000,000 acres were planted with hybrid seed corn in 1938 This is over one seventh of the nation's total corn acreage

It is safe to say that the growers who plant properly certified hybrid corn seed are not only increasing their yield per acre but are also insuring their crop to some extent against possible damage Under our present system of crop control, this insurance of crop yield and increased yield per acre is of even greater importance to the producer than in the past

[3] E M East and D F Jones, "Inbreeding and Outbreeding," 285 pp Philadelphia and London, 1919

[4] R W Jungenheimer, *Kansas Agr. Exp Sta Circular* No 196, 1939.

The possibility of utilizing heterosis in the improvement of other crops depends largely upon the practicability of producing the hybrid seed at a cost that will not be prohibitive to the grower An illustration of its use in an important vegetable crop is the recent report of two Russians, Selivanov and Alpat'ev[5] on "Heterosis in Tomatoes in the Canning Industry" Thirty-five varietal hybrids were tested All were earlier in maturity than either parent; eleven exceeded the better parent in yield by 20 to 51 per cent, ten by 10 to 20 per cent. and the rest were slightly superior or equal to the better parent. The hybrids were better developed and more disease-resistant than their parents and in fruit quality they were equal to the standard varieties The use of hybrid seed on the collective farms is recommended and the most favorable parental combinations are indicated Another possible use for heterosis is found in the production of faster-growing forest trees Experiments in this direction are being conducted by the Institute of Forest Genetics of the U S Forest Experiment Station Still another use for it may be found in the production of rapidly growing hard-wood trees like the black walnut

Turning now to the third phase, breeding for disease resistance, the pioneer work of W A Orton[6] extended from 1900 to 1911, and that decade of work by one man pointed the way to a more permanent agriculture In the following decade progress was slow, but by 1921 the work of Norton[7] on breeding asparagus resistant to rust, of L R Jones[8] on breeding cabbage resistant to fusarium and of G M Reed[9] on resistance and susceptibility of oats to various fungi had stimulated wide-spread interest in the combatting of plant diseases by the breeding of resistant commercial varieties. As a result, during the last twenty years new varieties which are resistant to fungus diseases or to insects or nematodes have been produced in such important field crops as barley, beans, cowpeas, cabbage, canteloupe, corn, cotton, lettuce, oats, peas, potatoes, sorghum, spinach, sugar beets, tobacco, tomatoes, watermelons and wheat

Much of the earlier work on disease-resistant varieties consisted merely of the selection of resistant strains out of old varieties But the classical work of Orton on breeding wilt-resistant watermelons began with hybridization of the watermelon and the field melon or citron because the latter was resistant to the disease, although of no value as a table fruit. By raising successive generations from this cross and repeatedly selecting seed from the most promising plants, wilt-resistant watermelons of commercial value were finally obtained Many of the problems involved in the breeding of disease-resistant varieties by hybridization are no more difficult than that of breeding wilt-resistant watermelons But in some cases the problems are complicated by the necessity of using distinct species having different chromosome numbers

As an illustration of this more complex type of problem, let us consider as briefly as possible some of the progress that has been made in breeding for resistance to the black stem rust in wheat This one phase of wheat breeding has a long history, including many interesting angles and details, it will be possible here merely to bring out some of the highlights in a varied panorama of agricultural activity

[5] M W Selivanov and A V Alpat'ev, *Plodoovoscnoe Khozjaistvo* (Fruit and Vegetable Growing), 1 21–24, 1938 (abstract in *Plant Breeding Abstracts*, 8 497, 1938)

[6] W A Orton, U S Dept Agr. Yearbook 1908 453–464

[7] J B Norton, U. S Dept Agr *B. P I Bull.*, 263, 1913

[8] L R Jones, *Wis Agr Exp Sta. Res Bull.*, 48, 1920

[9] G M Reed, *Mo Agr. Exp Sta. Res Bull.*, 37, 1920

The black stem rust has long been known as a serious menace to wheat production in all the important wheat-growing countries, and a great many efforts were made to produce varieties resistant to the fungus by the older and simpler methods of plant breeding In this earlier work only common varieties of wheat were used either as sources of new selected strains or as parents of hybrids The common wheats are varieties of *Triticum vulgare;* they all have 21 pairs of chromosomes; and none are known to be fully resistant to black stem rust The chief difficulties in breeding for resistance among the common wheats alone are (a) the natural variability (occurrence of physiologic races) in the parasitic fungus itself and (b) the fact that none of the many otherwise excellent *vulgare* varieties carry genetic factors for immunity to stem rust In spite of these difficulties a number of excellent new varieties that were partially resistant to the disease were produced by crossing common wheats and selecting in later generations But this was not enough to insure the wheat crop against possible loss from stem rust. As recently as 1935 an epidemic of black stem rust in North Dakota resulted in losses estimated at $100,000,000 Now it had been known for many years that some of the *Triticum* species having only 14 pairs of chromosomes were immune to this disease. A variety of *T dicoccum,* known as white spring emmer, has been grown in this country for at least 50 years and is known to be nearly immune to stem rust In 1920 Hayes, Parker and Kurtzweil[10] from the results of crossing this emmer with common wheat, predicted that the transfer of this near immunity from emmer to common wheat was possible This job, however, proved to be very difficult due to the high degree of sterility of the first generation hybrids and the linkage of resistance with undesirable emmer characters. It was not until 1930 that McFadden[11] of South Dakota succeeded in combining the rust resistance of Yaroslav emmer with the commercial qualities of Marquis, a valuable common wheat, through hybridization and selection As a result he introduced two new varieties, H-44 and Hope, and in the all-important mature plant stage these two varieties have been found nearly immune from all the physiologic forms of stem rust This important step made possible the production of many other nearly rust-free varieties by hybridization either of H-44 or Hope with other common wheats.

As one illustration of this last phase of the progress in wheat breeding, let me mention the work of our own experiment station in breeding a rust-resistant wheat for California Realizing that many California wheat-growers prefer the variety called White Federation, which is very susceptible to rust, Briggs[12] has developed a rust-resistant White Federation wheat by first crossing White Federation with Hope and then by repeatedly backcrossing the resistant hybrids to White Federation By a similar system of hybridization, followed by backcrossing selected hybrids to the variety into which resistance is being introduced, Briggs is working toward the combination of rust resistance with resistance to bunt or stinking smut and resistance to the Hessian fly, all in the same commercial variety

Meanwhile, the physiological nature of disease resistance is becoming better understood, not only in wheat but in many other crop plants At the same time the genetics of susceptibility, resistance and immunity, like the genetics of other important qualities, is being worked out for many different crop plants. As this knowledge becomes avail-

[10] H. K. Hayes, J. H. Parker and C. Kurtzweil, *Jour. Agr. Research,* 19: 523–542, 1920

[11] E S. McFadden, *Jour. Amer. Soc. Agron.,* 22. 1020–1034, 1930

[12] F N. Briggs, *Am. Nat,* 72: 285–292, 1938.

able to scientific plant breeders, the progress in plant improvement will become more certain, if not more rapid Concerning wheat, for example, Clark[13] states · "While much work has been accomplished with wheat, the peak of research surely has not yet been reached. Many problems remain to be solved, and even greater results than those obtained in the past may be expected in the future" In general, it is worthy of emphasis that future progress in plant breeding is to some extent dependent on more complete genetic analysis of all important crop plants First the tagging of the chromosomes, then the mapping of the chromosomes, as has been done in Drosophila, will give the only sure foundation for the breeding of new varieties "to order" Such genetic analysis is well advanced in maize, and some progress has been made with barley, garden peas, common beans, rice, oats, wheat, soy beans, cotton, flax, tomatoes and tobacco, as well as the garden snapdragon, Japanese morning glory, sweet pea and other ornamental flowers

As an illustration of a still more advanced type of plant breeding, let us consider the use of an amphidiploid hybrid in bridging two species which produce completely sterile hybrids Fortunately we have an interesting illustration of this from a recent achievement in breeding disease-resistant tobacco Commercial tobacco, *Nicotiana Tabacum,* is seriously affected by a virus disease called tobacco mosaic Now it happens that another species of *Nicotiana, N glutinosa,* is hypersensitive to this same mosaic virus, but because of this hypersensitivity each infected area is self-limiting and therefore *Nicotiana glutinosa* is, practically speaking, immune to the disease Dr F O. Holmes, of the Rockefeller Institute for Medical Research, was interested in breeding mosaic immune commercial tobacco. In the hope of introducing immunity from *N. glutinosa* into *N Tabacum,* he hybridized the two species, but all his first generation hybrids were completely sterile. Now it happens that two of my colleagues, R E. Clausen and T H. Goodspeed,[14] had been interested in the cytogenetics of *Nicotiana* for many years and, among the various experimental hybrids that they studied, were some between *N glutinosa* and *N Tabacum* These two species differ in many morphological characters and, as would be expected, the F_1 hybrids exhibit a combination of various characters from the two species Now *N. glutinosa* has 12 pairs of chromosomes, whereas *N Tabacum* has 24 pairs; so the F_1 hybrids should have 36 chromosomes, 12 *glutinosa* + 24 *Tabacum,* and because of this unbalanced relation between the chromosomes these hybrids would be expected to be highly or completely sterile. Such indeed proved to be true except for one of the F_1 hybrids, which proved to be fertile and which a year later produced a family of 65 plants which were uniformly fertile and were found to have 72 instead of 36 chromosomes Evidently the original fertile hybrid plant arose from a doubling of the chromosome number immediately or soon after fertilization by which a tetraploid hybrid with 36 *pairs* of chromosomes was produced; and these 36 pairs consisted of the normal diploid complement of *glutinosa* + the normal diploid complement of *Tabacum.* In other words, the fertile F_1 hybrid was an amphidiploid and, since each parental set of chromosomes behaved normally in gamete formation, the hybrid was fertile and when selfed produced a uniform family of amphidiploids This new type, combining characteristics from two very distinct species, was named *Nicotiana digluta* Since *digluta* has a complete complement of *glutinosa* chromosomes as

[13] J. A. Clark, U. S. Dept. Agr. Yearbook, 1936. 207–302.

[14] R E Clausen and T. H. Goodspeed, *Genetics,* 10 · 278–284, 1925

part of its hereditary mechanism, it of course carries the factor or factors for hypersensitivity to the mosaic virus So when Holmes appealed to Clausen for suggestions as to how he might introduce this practical immunity into commercial tobacco, Clausen sent him seed of *N digluta* and suggested a plan of procedure. By crossing *digluta* with several varieties of commercial tobacco and backcrossing mosaic-free hybrids to the *Tabacum* parent repeatedly for several generations, Holmes has established several new lines that have the characteristics of commercial tobacco and are as immune to mosaic as *glutinosa* A cytogenetic analysis of just what took place among the chromosomes in achieving this result has not been made One possible explanation is that a translocation occurred between the *glutinosa* chromosome carrying the hypersensitivity gene, the N factor of Holmes[15] and one of the *Tabacum* chromosomes The true explanation must await further cytogenetic research Meanwhile, this experience in tobacco breeding illustrates how practical results are sometimes obtained without our knowing the exact scientific explanation of how they happened It also provides a fine illustration of an important practical application following upon a purely theoretical achievement, namely, the discovery of the amphidiploid hybrid, *Nicotiana digluta,* which was a gift of nature

It should be noted that the same objective could have been reached if Holmes had had a tetraploid form of *Tabacum* with which to work instead of *N digluta* By crossing such a tetraploid with *N glutinosa* his first hybrid would have had 12 *glutinosa* + 48 *Tabacum* chromosomes just as before, and the same program of backcrossing to commercial tobacco would have been in order

This brings up the subject of the artificial production of tetraploids from diploids and of amphidiploids from normal first-generation hybrids between species And this is only one phase of very important recent developments in cytogenetics It will serve to introduce the concluding portion of this paper in which a brief review will be attempted of recent progress in plant breeding technique.

Several different methods are known by which the chromosome complement of a plant may be doubled In briefest summary these are as follows First, the the decapitation method of Winkler[16] has been used recently by Greenleaf[17] with certain modifications in the production of amphidiploids from F_1 hybrids between species of *Nicotiana* Second, subjection of the plant to abnormal temperatures for the purpose of accelerating or retarding the process of cell division has been used by Randolph[18] and others with success Third, the use of x-rays and other types of radiant energy on seeds, pollen and other parts of the plant, as discovered by Goodspeed[19] is a possible method of producing tetraploids Fourth, the application of various poisons will retard cell division, as was first demonstrated by Němec[20] in 1904, and will sometimes result in tetraploid offspring, as has recently been proved by Nebel,[21] Blakeslee and co-workers[22] and many others

Following the artificial induction of tetraploids of a given species or variety, it is a simple matter to obtain triploids by crossing tetraploids with diploids.

15 F O Holmes, *Phytopathology,* 28 553–561, 1938

16 H Winkler, *Zeitschr Bot*, 2. 1–38, 1910

17 W H Greenleaf, *Jour Heredity,* 29 451–464, 1938

18 L F Randolph, *Jour Agr Research,* 50· 591–605, 1935

19 T H Goodspeed and A R Olson, *Proc Nat Acad Sci*, 14 66–69, 1928

20 B Němec, *Pringsh Jahrb. Wiss. Bot*, 39: 645–730, 1904

21 B R Nebel, *Biol Bull*, 73 351–352 (Oct), 1937, *Nature,* 140 1101 (Dec), 1937

22 A F Blakeslee, *et al*, Carnegie Inst Wash Year Book No 36 38–44 (Dec), 1937

Since triploids are generally highly or completely sterile, it is sometimes possible to produce vegetatively propagated seedless fruits of great horticultural value by this method Whether in the production of seedless fruits or in the creation of amphidiploids which may be directly useful or used indirectly in further breeding operations, the saving of time in obtaining the desired result stands out as an important consideration

Other valuable time-saving techniques have been devised in recent years, of which the following will serve as examples By artificially controlling the length of daylight, two varieties or species which normally flower at different times may be brought into bloom simultaneously, thus facilitating hybridization between forms with short-lived pollen Vernalization, or advancement of the rate of development of plants by means of pretreatment of the seed, provides another way of synchronizing the flowering periods of unlike species and varieties Whole plants or flowering branches of one variety or species may be kept in nutrient solutions of chemicals or in cold storage, thus insuring available pollen for crosses on another variety or species In the work of purification of material by repeated inbreeding or in repeated selection in successive hybrid generations, time can sometimes be saved by growing successive generations alternately in two different localities without waiting for recurrence of a favorable season in a single location. In this connection artificial methods of breaking the normal rest period of the seeds are sometimes utilized

One of the most interesting and valuable time-saving techniques is the culture of embryos in nutrient media The use of nutrient media in the culture of orchid seedlings has been a standard procedure for years The possibility of using this method to insure germination and hasten development in other genera which are normally slow and irregular in germination does not seem to have been appreciated until recently Dr W E Lammerts, of the Armstrong Nursery Company, is engaged in the breeding of roses and peaches and some other fruits In order to hasten germination and subsequent development, he removes the coverings from the embryos and places each embryo in a small vial of nutrient agar The majority of the embryos germinate promptly and can soon be transferred to tiny pots of sand in the greenhouse, after which they are carried along by transplanting as rapidly as possible Dr Lammerts writes (unpublished data) that he has obtained a flower on a hybrid rose seedling within six months after culturing the embryo He also states that vitamin B_1 has been very effective in giving higher percentages of germination in certain cultures where the embryo failed in many cases to form roots Also the number of roots is much greater in the vitamin treated cultures than in the controls, so that transplanting to the little sand pots is easier Furthermore, in hybrid peaches the embryo cultured trees develop more rapidly For example, from peach crosses made in the spring of 1936, 123 trees were grown from cultured embryos and 117 from seeds germinated by the usual method of stratification Of the 123 embryo cultured trees, 113 flowered and 71 fruited in 1938, whereas, of the 117 grown from stratified seeds, only 65 flowered and 36 fruited in 1938. Also there was a greater number of flowers per tree in the embryo cultured group Dr Lammerts is cooperating with Dr Bonner of the California Institute of Technology in testing nicotinic acid, theelin and ascorbic acid as aids in the embryo culture work Regarding roses there seems to be no doubt that embryo culture is worth while, and as for peaches Lammerts is convinced that embryo culture pays for the following reasons (1) the higher percentage of

germination obtained; (2) the securing of a more representative random sample as a result of the higher percentage of germination; (3) the speeding up of the life cycle so that a two-year breeding program can be followed. Perhaps the most outstanding results are those obtained with apricots, which are well adapted to embryo culture technique, both as regards high percentage of germination and rapid, vigorous growth of seedlings

Even in so brief a discussion of technique as this, one must not fail to mention the importance of cytology in plant breeding and to acknowledge the debt we owe to such pioneers as Belling, who devised the iron-aceto-carmine smear method as an aid in the rapid determination of chromosome numbers This method with its many later modifications has perhaps done more for the advancement of plant breeding than any other single technique Many of the demands made of the plant breeder can be met only by the use of two or more distinct species The well-informed breeder, about to start a new project, will insist on knowing the chromosome numbers of the species and forms with which he must work; and in all such projects the frequent checking of the chromosome situation is important In certain groups of plants, such as, for example, the grasses, sexual reproduction may be absent, the seeds being produced by some type of apomixis The importance of advance information concerning such a situation must be obvious New cytological techniques are continually being developed to meet such needs.

Reference should also be made to the use of improved statistical methods in the interpretation of plant breeding data, and to the value of applying statistics in the preliminary planning of such operations as comparative progeny tests as a basis for selection; see Fisher's "The Design of Experiments."[23] The recent work of Harrington[24] on the number of replicated small plot tests required in regional variety trials is a good illustration of the scientific solution of such a practical problem. Lack of time prevents more than this passing reference to a very important phase of recent progress in plant breeding

In conclusion let me mention the importance of research as the basis for future progress in plant breeding, especially the significance of current research in the field of physiological genetics It is safe to say that the relations between the chromosomes and the cytoplasm, on one hand, and the morphological and physiological characters of the plant, on the other hand, seem likely to be more clearly understood in the near future New light on the genetics of size and of growth and form of the organism and its parts may lead to a better understanding of heterosis and to a more successful utilization of this phenomenon Research on the genetics and physiology of development in plants is just getting under way, but it gives promise of future enlightenment which will have an important bearing on breeding for such qualities as yield, chemical composition and resistance to cold, drouth, diseases and pests The artificial distinction between "pure" and "applied" research can no longer be maintained in general, it seems certain that henceforth scientific research on plants and scientifically practical plant breeding will go hand in hand in the service of society

[23] R A Fisher, "The Design of Experiments," 252 pp. Edinburgh and London, 1935.

[24] J B Harrington, *Jour. Amer. Soc Agron*, 31 287–299, 1939

THE LAST EPIDEMIC OF YELLOW FEVER

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WITH mingled emotions of doubt and desire, we received the reports of the epochal experiments of Dr Walter Reed and his notable associates on the field of Quemados in Cuba in 1900 When we were told that these remarkable men had demonstrated that yellow fever was conveyed only through the bite of a common house mosquito, then called Stegomyia, we were amazed and incredulous, yet longing to believe it were true I recall vividly the conference with Chief Justice Albert H. Whitfield, of the State Supreme Court, soon after the results of the experiments were reported As we sat on the porch on a fine spring afternoon, Justice Whitfield, from his wide knowledge and much wisdom, spoke of his experiences in several fever epidemics, his consultations with veteran physicians and his talks with intelligent men and women who had been in personal contact with the ravages of the disease The apparent facts that he had gathered from these different sources made it difficult for him to accept the conclusions of the Army Commission of surgeons. At the conclusion of our conference he went slowly and thoughtfully down the walk, shaking his head in doubtful protest, and I imagined him soliloquizing: "Can it be possible that these epidemics of yellow fever which have ravaged the South again and again, closing the schools, eliminating railroad trains, shutting down factories, closing stores, depopulating cities and villages, paralyzing all activities and killing hundreds of people—can it be possible that all this has been brought upon us by a tiny, insignificant mosquito?"

We waited for further details of the experiments and for a practical demonstration of the conclusions of the commission It came more quickly than we expected and with indisputable proof when Major Gorgas in 1901 exterminated the fever in midsummer from the city of Havana, a permanently endemic center of the disease A few years later, if added proof were desired, it came again when the epidemic of 1905 in New Orleans was promptly abated and completely exterminated before the natural exterminator, the ever dependable frost, had come to do its work Then we had to believe, and with what profound and grateful relief we accepted the verdict!

But the results of all this great work came after the epidemic of 1898 At that time we were firmly entrenched in our age-old belief in contamination from personal contact, from clothing and bedding used by fever victims and from other unknown, mysterious sources The phase of the fever epidemics that frightened us most and was most responsible for the mad hysteria which always seized us was the inscrutable, utterly incomprehensible source from which infection came "It was the mystery of its [fever] onset and the strange unaccountable manner of its propagation which chilled the heart and struck terror to the bravest " With this background, the epidemic of 1898 began its career and suddenly came upon us in late September in our quiet, peaceful college community in Mississippi

"Both cases are genuine yellow fever There will be a meeting at four o'clock in front of the secretary's office to decide what we are going to do " These were the words of the messenger, riding his wheel at full speed, and stopping at each house just long enough to deliver his message

To those living in more northern lati-

tudes such a message could scarcely come, and its full portent could never be realized But here in Mississippi, where frost before November is unusual, the herald left behind him men and women with pale, awe-stricken countenances, who knew not when or how this mysterious, deadly malady, "this pestilence that walketh in darkness," might strike them

For forty-eight hours, since our local physician had divulged his suspicions and an expert diagnostician had been telegraphed for, we had met by twos and threes and fours, always with this question on our lips—"What were you going to do if the specialist pronounces it yellow fever?" Aye, there was the rub What *were* we going to do? Had we been "exposed"? If so, then by going north to cooler latitudes, we would run the risk of almost certain death were we to "come down" with the fever Could we get a special train to St Louis or Chicago? We probably could, but we would certainly be locked within and not allowed to stop south of Cairo, Illinois Besides, if some one should happen to be stricken with the fever in the closed car, all, according to the current belief, would become exposed and have to remain in quarantine for days in St Louis in addition to running the risk of a "spell" of fever in a cool region Later, the problem became further complicated because of a dinner party held two or three evenings before, one member of which had been taken to the infirmary, where his illness had been diagnosed by the expert, Dr H A. Gant, as a case of yellow fever No doubt the onset of the fever began the day of the dinner At least several now recalled that he looked languid and tired that evening In the event that this was true, every one present must be regarded as a possible victim of infection and, therefore, a dangerous person with whom to associate Who would care or scarcely dare to ride for eighteen hours in a closed railroad coach with these potential disseminators of this dreadful disease?

Dr Gant's report of his inspection of the cases of illness at the college is of interest especially as it indicates the great fear of this dread disease The people had gathered at the station to meet the "Special" which was bringing the expert, but they gave him a wide berth as though he might, in some mysterious way, be a source of danger. Dr Gant says:

> As I stepped out of the coach, I noticed the people all gave way and allowed me a broad road to a horse and buggy being held by a negro man Some one called to me, 'There is your buggy, Doctor,' and when I reached the negro he said, 'You just follow that buggy ahead of you, that man will lead you to the College' General Stephen D. Lee was one of the noblest and bravest of men but when we met on the Campus, and I made the announcement of the fever, he turned pale and looked almost as if he would faint, such was his anxiety and distress

The time was now past for argument concerning contagion versus non-contagion from personal contact In this hour of hysteria, any commonly reputed way of "catching" the fever was accepted as a probability from which escape was to be provided at any cost Why not go into the country and stay at a farmhouse for a few weeks? "You will have to face a shotgun first," grimly remarked our venerable professor of English True enough We had forgotten for the moment that in less than two hours after the telegram was sent for the specialist the campus had been surrounded by guards from the nearby town armed with shotguns and placed at intervals of one hundred yards, thus completely hemming us in from the outside world

At four o'clock, we met in compliance with the messenger's notice Some one had already definitely ascertained that a special train, with the restrictions before mentioned, would be furnished within twenty-four hours for those who wished to go to St Louis This necessitated, at least, a fifteen-hour ride mostly during the night, locked within an ordinary and crowded day coach with the added risk of all being exposed to the fever. But

men and women were panic-stricken. Reason had taken wings and had flown out of the window. All acted on the one idea of getting away and at once. The writer, never having had any experience with yellow fever and being unable to sense the great danger, chose to remain behind From this distance in time and experience, it must be acknowledged that we were excellent exemplars of Pope's aphorism, "Fools rush in where angels fear to tread"

The decision was soon made and the request for the train put in at once. After the usual uncertainty and delay in matters of this kind, it was finally ascertained that the train would leave the village of Starkville, one and one-half miles distant, some time during the following afternoon Fortunately, this branch of the Mobile and Ohio ran directly through the college grounds, a situation which forestalled any personal complications with the guards surrounding the campus Since the final announcement of the train's schedule, there was left no more than time to bring together haphazardly the necessary articles for a month's absence It was an occasion of frantic, bewildering haste, with homes and chattels left as they stood Dwellings were left with doors unlocked, indeed, with some standing open as the occupants had rushed through and away. This was no time to think and plan for the care of the inanimate things left behind The preservation of life was too absorbing to worry about material possessions

Since this was to be the last train out and the last opportunity to communicate with our faraway friends and relatives, we wrote many hasty letters to be mailed in St Louis by the courtesy of our departing neighbors Years afterward, I saw one of the letters we had written It was punched through with many jagged holes in preparation for the thorough fumigation it had received in St Louis in accordance with the futile practices and regulations of the time. We who stayed behind were a trifle doubtful, but having made up our minds, it seemed weak and vacillating to change, so we watched the train disappear in the distance and returned courageously to our home With the departure of the train, we realized that the campus had been the scene of a modern exodus The empty houses, the lack of a familiar face or voice to greet us and the suddenly hushed activity had changed its aspect to that of a deserted village. Our emotions were many and mixed, not the least of which concerned the matter of life and death during the next few weeks

The yellow fever special carried two day coaches, one for the inhabitants of the near-by village who wished to get away from all danger of the fever and one for the people of the college Instructions had been issued by some official to lock the doors of the latter coach in order to prevent its passengers from wandering outside and exposing persons with whom they might possibly come in contact while enroute, but that perversity in human affairs which often upsets carefully made plans confused the orders and the town people were locked within their coach, while the supposedly dangerous college individuals were allowed their freedom At the time it seemed the height of irony, but after the danger had passed it became the subject of much good-natured banter It is fortunate that we can still look back upon our past predicaments with a refreshing sense of humor

Probably no one except an occupant of the coach can ever adequately describe that night ride to St Louis The few individuals who had been guests two or three evenings before at the dinner party were a particularly disturbing element. Every one feared them, and although they were beloved neighbors a few days before, they were now objects of suspicion and fear to be shunned and set apart. It

was scarcely possible to get far from them in a coach where standing room only was to be had for some, and the floor, in the aisle, was crowded with sleeping children A near and dear relative of one of the dinner party, with studied avoidance of her intimate kin, established her family at the opposite end of the car for such fancied protection as this short distance might afford To such lengths will most of us go under the impelling stress of ignorant fear. The night was undoubtedly one of real terror to all of those old enough to realize the danger as the current knowledge depicted it. Every person looked at his neighbor with distrust and suspicion, expecting any moment to see the dreaded thing strike some one Every known or suspicioned headache, every flushed cheek, every touch of nausea or evidence of faintness invoked a sudden fear and aroused an unreasoning emotion of imminent danger Nor did this fear of each other end on leaving the train in St Louis There, each family went its own way to find rooms remote from former neighbors until the fruition period of possible infection had surely passed

The campus was divided by the railroad into a north portion, the college proper and a south portion, a residential section; and, if my memory and coexistent notes serve accurately, we were the only family left on the south side There were two other individuals of whom we shall speak later Every family and individual were isolated and, in general, warned not to approach any nearer each other than fifty yards This regulation was facilitated by the number of comfortable, empty houses available. Colored servants were plentiful in those days, but when we returned to our home from seeing the train away not one was in evidence—Aunt Emmeline, the cook, Eliza, the laundress, and Early Washington Livingston, boy-of-all-jobs, had melted away, vanished like the dew on a summer morning. They were wise, albeit fear was the basis of their wisdom. One belated colored man attempted to scale the fence too late and not obeying the command to halt, received a charge of small shot and lost an eye, but somehow eventually got by. We took this lesson to heart, for we knew then beyond the possibility of a doubt that the guards meant to carry out their instructions

The two individuals living on our side of the campus were General Stephen D. Lee, president of the college, and W. H. Magruder, head of the department of English In the area within the cordon of guards these men organized and directed all the activities and saw to it that the regulations were carried out to the minute General Lee was a man slightly over six feet in height with a physique in full proportion He was still every inch a soldier, with an austere, positive and sometimes domineering temperament, especially when excited I recall a visit to his office when I found him pacing up and down the floor rehearsing a speech which he was to deliver later at the commencement exercises of the State College of Iowa I had no more than crossed the threshold before he came at me like a lion and shaking his fist, exclaimed, "Sir, we had the argument, we had a right to secede and you had no right to coerce us " What little equanimity I might have had under normal conditions fled completely, and I stammered: "Yes, sir, General, no doubt, no doubt. You know, sir, I was born several years after the war and really, I–I know nothing about it " Immediately he smiled and became at once solicitous toward my request for funds for some small equipment to facilitate the work of the department over which I presided Notwithstanding his stern demeanor he was as sympathetic and compassionate as a woman This gentle quality of his character was evident in his tender care of an invalid wife and his loyal devotion to her through long, busy years. General

Lee will always occupy a warm and secure place in my affections for the sympathetic and loyal backing he gave to a young Yankee in the early years of his career.

W H Magruder was another intrepid soldier who still carried the scar of a bullet received through his cheek at Kenesaw Mountain, where he nearly gave "the last full measure of devotion" to the South from doing his part in an effort to stop Sherman's march to the sea. These two fearless men, compatriots in a devastating civil war, were now companions in a fight against a mysterious foe scarcely less destructive of human life They were ably assisted by Dr W. H Barr, a calm forceful man with a delightfully dry wit, afraid of nothing and no one He was continuously on duty, caring and prescribing for the sick, watching with an eagle eye over the well, directing the sanitary arrangements and finally, if need be, ready to assume the functions of an undertaker for those who might die This faithful, enduring man cheered and inspired every one during those long anxious days A good physician often becomes a great humanitarian

The two old soldiers were rejuvenated and fired again with the martial spirit which had long lain dormant during years of civil duties. Both sat their horses well and every morning and evening they rode in company around the campus, and halting at some distance before each house, would halloo to the inmates If we answered the call all was well, greetings were exchanged, inquiries after the patients were made, speculations regarding the probable time of the first frost were offered and they were gone until another day wore itself around If perchance the occupants did not respond, it was understood that the doctor would be notified and we would be taken to the infirmary, where the fever would have to run its course. There was no sure escape from the disease except to run away from it. If one elected to stay with an epidemic he simply chose to take the serious risk of a chance infection.

Our first act was to ascertain whether he would be able to get food and supplies. We found that one grocery store in a village of three thousand inhabitants remained open, ready for service Business was at a standstill—those stores whose proprietors had not already left found they might as well close and save the expense of upkeep; but the conditions in the village were not nearly as serious as they would have been had the fever actually been present among the inhabitants Many towns in the state in which cases of fever were present were literally deserted during the danger period It was arranged that the supplies from town should be delivered at the campus gate, from whence one of the guards would bring the packages one hundred and fifty yards inside and then retire, allowing us to come forward and get them It soon transpired, however, that a fearless employee of the college was willing to gather up the food and distribute it by leaving the packages at a very respectful distance in front of each occupied house, where we could get them with little trouble and without danger of coming in contact with any one A little later we were notified that milk and butter would be furnished gratis from the college farm Milk we had, for one of our neighbors had left his cow in our care and we were pasturing it in our other neighbor's lot, while our horse was turned out to the common It will be noted that "horse and buggy days" could be real interesting

During the first few days of the siege it seemed that we were perforce to become vegetarians, for the source of our meat supply had vanished, but we had not realized the resources of a college farm. We were most agreeably surprised to receive early notice that meat from animals slaughtered on the farm would be furnished at frequent intervals. Still later came an order informing us that small

quantities of vegetables from the grounds of the horticultural department would be distributed daily No center of infection during this state-wide epidemic could have been as favorably situated as we were in this limited area. Certainly we had never before and have never since lived with less personal expense than during that long month of waiting We had little thought, however, for that phase of our existence Indeed, the social and economic ills of the world were forgotten for the moment, a happy compensation for our many anxieties

When people are confined within a definite enclosure knowing there is no chance of getting out for weeks, even a half-acre lot becomes small and monotonous. The enforced absence from technical books and the laboratory irked, perhaps, the most, although not as profoundly as it would have in later years when these tools became more vital elements in my life and work We made as much as possible of the household duties, and happily there were no restrictions on thinking It was a grand opportunity, if one could forget the implications and dangers of the situation, to think and plan for the future. We had the assurance that nature would eventually rescue us if we were fortunate enough to escape the mysterious sources from which the fever came Why or how the friendly, hoary frost eliminated the disease no one knew—that it did, however, was a well-known and thoroughly established fact Had we known that the Stegomyia mosquito became inactive at temperatures below 60° F and that it quickly died at temperatures below 40°, it would have had no meaning for us We should have regarded it simply as an interesting bit of knowledge wrought out of the biological world by an inquisitive genius bent on prying into the secrets of living things The baffling mysteries which surrounded yellow fever previous to the discoveries of the Reed Commission seem to-day almost incredible Dr. G Farrar Patton remarks, "Nowhere in the history of scientific research is there a more conspicuous instance of the tenacity with which nature seems to guard her secrets than in the long and deadly struggle it cost mankind to wrest from her the secret, so priceless yet so simple when discovered, of the causation of yellow fever" The Stegomyias hummed merrily around us, but we knew nothing of their potentially dangerous qualities—they were merely annoying mosquitoes, nothing more The individuals with which we came in contact were certainly uninfected with the causative organism of the fever None of the mosquitoes carrying infection reached our end of the campus or, if they did, they failed to reach us

Experience had shown that during an epidemic of yellow fever a certain percentage of the cases would terminate fatally Therefore, General Lee, with his penchant for organization, notified the few unmarried instructors who had chosen to remain on the campus, that they would meet the next morning to go over the adjacent field with the worthy purpose of selecting a site for the burial of any chance victims of the fever It is one thing for a young man to select a lot in a cemetery in which he may rest in the dim, distant future and quite another matter to choose a site for a grave in which he may lie within the week The doleful, anxious countenances, the lagging footsteps and the total lack of enthusiasm for the expedition were painfully evident, especially in the face of the general's cheerful enjoyment of another opportunity for organization. The crest of a ridge in an open field just east of the campus was chosen with little argument, and they hurried away from the grim business The incident gave the General a fine opportunity to chaff the young men for their apparent lack of those qualities of stern courage which he maintained should characterize a soldier

under fire Happily, not one of the nine officially reported cases of fever proved fatal, and the emergency burial field remains still unoccupied

This zero mortality was undoubtedly due, in large part, to the constant attention and skilful treatment given the patients by Dr Barr, to the care of the faithful nurse in attendance and to the excellent facilities of the college infirmary Available statistics from twenty-seven cities and villages in the state report a total of 747 recognized cases of fever, with a death list of 51, a mortality of slightly less than 7 per cent

How anxiously we watched and waited for an early frost. We noted the furry Isabellas scurrying along in quest of winter retreats and recalled the old saying, "hurrying caterpillars and an early fall," hoped and prayed it might be so, and it was so It came during early November, and had we been pagans we would certainly have elevated frost to the status of a god and held a festival in his honor One could feel the great shout of relief and joy throughout the land. The twinkling fires of the guards died out, the shivering men hurried home to their own firesides, the exiles returned, normal activities began, the college opened on the 15th of November, and the last wide epidemic of yellow fever was at an end

It was a few days over two years, however, before we knew that never again were we to pass through a similar experience. Late in the evening of December 31st of the year 1900 Walter Reed from the Barracks in Quemados, Cuba, wrote to his wife in Baltimore.

Only ten minutes of the old century remain Here I have been sitting reading that most wonderful book, "La Roche on Yellow Fever," written in 1853 Forty seven years later it has been permitted to me and my assistants to lift the impenetrable veil that has surrounded the causation of this most dreadful pest of humanity and to put it on a rational and scientific basis. I thank God that this has been accomplished during the latter days of the old century May its cure be wrought in the early days of the new! The prayer that has been mine for twenty years, that I might be permitted in some way at some time to do something to alleviate human suffering has been granted! A thousand Happy New Years! . Hark, there go the twenty-four buglers in concert, all sounding "Taps" for the old year

History holds many lessons for us, and it may be well to have recalled something of the suffering and economic losses caused by past epidemics of yellow fever, although it is improbable, thanks to our knowledge of the epidemiology of the disease, that this country will ever suffer again from its ravages During the years following Reed's discovery, the work of eliminating the fever from this country went along rapidly and successfully By 1927 it was thought that the disease had been practically eradicated from the Western Hemisphere Then suddenly a most perplexing situation arose—urban epidemics of the fever developed in certain South American cities Again, the matter was clouded with mystery From whence came the infection? Where and what was the source from which the virus came that started these epidemics? Fortunately, we have in this country a marvelous institution ready and eager to engage in an effort to solve the difficult problems affecting the physical ills of mankind The Rockefeller Foundation, the watchdog of the ills of humanity and probably the greatest single independent agent for the amelioration of those ills, began an investigation at once An intensive survey disclosed that vast areas of the hinterland of South America are endemic centers of "jungle yellow fever" in regions where *no Stegomyia mosquitoes* exist These rural reservoirs of permanent infection serve as a source from which the fever is carried into densely populated areas of cities inhabited by Stegomyia and an epidemic ensues Surprisingly enough, additional species of mosquitoes, other than Stegomyia, in the jungle areas have been incriminated as

"natural vectors of yellow fever." Thus the problem involving this disease has again become complex and greatly broadened in its aspect. One naturally inquires regarding the significance of this new development for the United States.

It is hard to realize that instead of a distance measured by a voyage of a week or more, we are now within a flight of hours from the cities of South America; and as Dr. V. G Heiser says, "A mosquito loves to ride in an airplane as much as a dog does in an automobile Open a door a crack to either one and he or she will hop in." Unquestionably mosquitoes are capable of riding for many hours in an airplane and arriving at a landing field in an active, lively condition. Moreover, infected mosquitoes are probably just as eager and able to ride in an airplane as uninfected ones. It therefore seems not at all impossible for yellow fever to be reintroduced into this country.

We must not forget, however, that Walter Reed and his associates have lifted the impenetrable veil surrounding this disease and have "put it on a rational and scientific basis." As a result, the prophylactic measures that have been developed for the control of the fever indicate, with some degree of assurance, even though infected mosquitoes may be brought to this country in airplanes and though the insects may bite non-immunes, thus initiating sporadic cases of the fever, that it is highly improbable for a *wide-spread epidemic* of the disease ever to develop again in the United States. This assurance, however, should not, for a moment, cause any relaxing of our attitude of watchfulness regarding the re-entry of the fever into any locality in this country Physicians in southern areas, especially, should always keep familiar with the symptoms of the disease and be able to diagnose a sporadic case or, at least, to become sufficiently suspicious of the case to isolate it at once, thoroughly screened from any possible access by mosquitoes. The fact that the virus of the fever can be carried from a stricken individual *only by a mosquito* still holds the problem within the limits of reasonable assurance of control.

THE RURAL COMMUNITY AS A SCIENCE LABORATORY FOR CITY CHILDREN

By Dr. N. ELDRED BINGHAM

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SCIENCE plays an ever-increasing role in shaping human lives. As man has learned to use power-driven machinery in producing food and other raw materials a larger and larger proportion of the population has been freed for other activities Mass production of standardized goods by power-operated machines coupled with the rapid evolution of transportation have hastened migration to large cities where individuals are more and more dependent upon others for the goods and services they receive Each new scientific discovery seemingly adds impetus toward specialization, standardization and remoteness of consumer from the production of the goods he uses

Urban students have little opportunity to participate in experiences familiar to most rural boys and girls. Of course, city children do have many unique opportunities for the study of science in museums, in zoos and in botanical gardens They also have closer contact than rural children with large-scale construction work, manufacturing establishments and advanced means of transportation

Rural children, however, can learn much science through participation in such farm activities as caring for the farm water supply, furnishing heat for the house, maintaining sanitation, controlling insect pests, draining and cultivating the soil, growing, harvesting and storing crops, feeding and caring for animals, constructing and repairing farm buildings, using simple tools, operating farm machinery and the curing of meats for the family Needless to say, these experiences must be pointed up for most children

Both public and private schools are endeavoring to furnish concrete vital experiences like those mentioned above Some have a farm school, some a school farm, some a school forest, some a school camp, and others plan short week-end trips to the country This paper describes the science aspects of the rural study trips conducted by the Lincoln School of Teachers College for its ninth grade during the past two years The second year the Alfred P Sloan Foundation financed these trips The social science aspects of one of these rural trips and other school trips are reported in two recent articles [1, 2]

Early during the 1936 school year ninth grade pupils and teachers felt the need of first-hand experiences in vivifying the theme of their integrated course, "Living in a Machine Age" A plan was presented to the parents They agreed to finance a week's study in a farming region in western Massachusetts, so both pupils and teachers of the ninth grade moved to and lived for a week in the homes of local families in a rural Massachusetts town Upon arrival at their destination some discussion around the fireside was essential to familiarize the boys and girls with kerosene lamps and lanterns and the hazards that accompany their use, with sources of drinking water and with the location of wash-rooms and toilet facilities. They needed to plan for their share in the preparation of the following day's meals, their responsibility in

[1] Alice Stewart, *Teachers College Record*, 39 494–505, March, 1938.

[2] Elmina Lucke, *Progressive Education*, 15 617–628, December, 1938

UNLOADING FUEL SLABS

caring for their own beds, and their co-operative effort in keeping the bedrooms, wash-rooms and toilets in a sanitary condition. Because the farms were located near state forests and because the nearest neighbors were about a half mile distant, pupils were cautioned against getting lost.

In this environment opportunity was provided for all the pupils and teachers to participate in varied activities common to rural youth. These city students also took short trips to study the natural environment and local industries The problem of soil conservation and flood control was dealt with in a visit to a local reservoir and to a lumber mill operating in a nearby woods The problems related to general and specialized farming were met in trips to neighboring farms The problem of the relation of industry to its natural environment was seen in a visit to a granite quarry and to a paper mill The problem of the maintenance of health was faced in a visit to the country doctor and to the County Health Center.

In the country heat doesn't just come in steam radiators Fires must be stoked. This requires fuel, and limited supplies on hand must be replenished So a local truck and the farm car and trailer were used in hauling slabs

Barbara summed up the experience this way·

> We bumped up a double rut to a clearing where the wood was strewn around in piles and started a double lineup Some cooperation! I personally didn't do much work but I can't say the same for everyone else They all worked away for an hour or so passing planks along to me and the truck When we quit the truck was piled and then we got on top Coming home was a mechanical elephant ride and we were hours late for dinner Maybe work is only $F \times D$ but it certainly is exhausting

This experience lasted long enough for boys and girls to learn to work together, to use the laws of inertia effectively, and to work in rhythm They got the thrill of achievement in learning to use their bodies efficiently and in cooperating with others doing a like task The fact that they hauled eleven cords of wood during the day testifies to their intelligent participation and appreciation of the way a job can be done cooperatively on a farm

Since all could not share in hauling slabs at one time, a second group went to visit the nearest farm, a self-sufficient venture of two bachelors, and a third group collected apples for cider making

At discussion time the group that had visited the farm shared their discoveries They talked of butchering and curing meats, of making bread, butter, cheese, jellies, sauerkraut, of keeping vegetables over the winter and of preserving eatables in summer in a cellar refrigerator Taxes, home-made clothes, renting the right to pick berries, selling milk and feeding hunters in the winter time—all these items and many others opened up new vistas of economics for our urban boys and girls

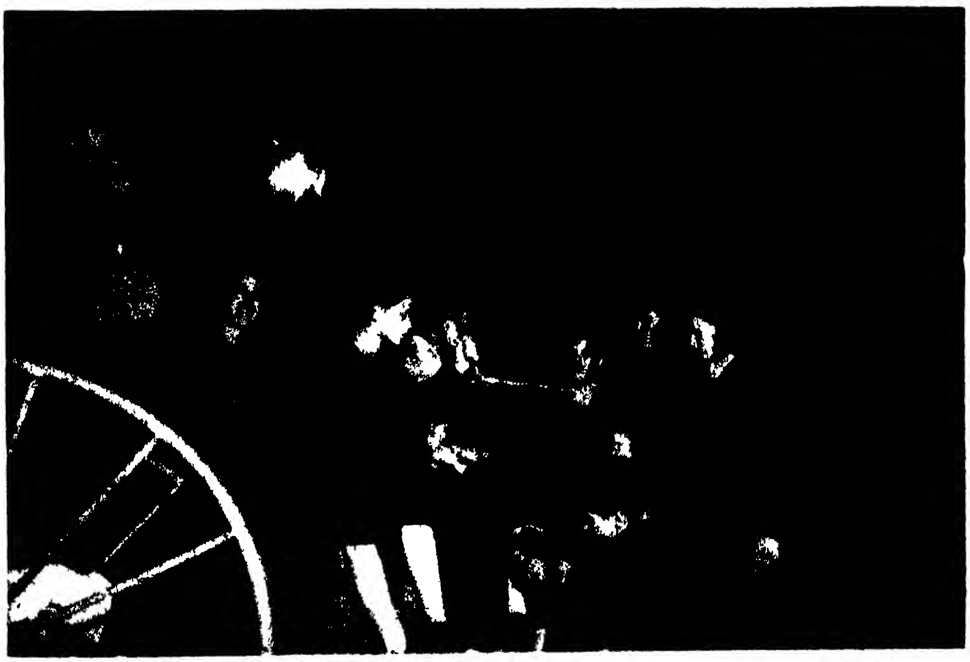
The group that had gathered apples made cider from them Experience in studying and operating the hand mill enabled them to see how a train of gears was used to gain speed for the fly wheel, how the inertia of the flywheel kept the mill going evenly and how the application of a small force at the end of a long lever to the worm gear of the press exerted a tremendous force on the apple pulp

Muggy said this with regard to the cider making

> At first we made only one gallon per bushel. Then we were told to use a burlap bag (in the press, which we did), and got almost two gallons per bushel The cider was marvelous We made eight gallons and drank some of it at the barn dance the next night

The second step in the preparation of the fuel was the cutting into short lengths with a buzz saw Power was secured from a farm truck by replacing one rear wheel with a belt pulley The pupils helped set up the machinery, handled slabs, and piled the cut pieces in the wood shed

The following evening's discussion centered around the use of inertia in work Examples given were the throwing of wood from one to another, the momentum of the fly wheel on the cider mill, and the use of inertia in lifting wood from the slab pile. One girl mentioned the gain in momentum when cycling down



MAKING CIDER

NAILING BATTENS ON THE GARAGE

hill and the necessity of using the engine as a brake when going down grade with a heavy load

The use of the transmission gears when hauling heavy loads up hill was discussed Some one raised the question of why both rear wheels of the car did not turn when buzzing wood This focused attention on the car differential Fortunately, there was an old one in the barn which some of the group decided to take apart Shortness of time prevented their completing this project while on the trip Later in the classroom they demonstrated the differential so well that the entire class achieved a good understanding of its operation

There were queries of why the belt was twisted between the pulleys, how hard the Ford engine was working when the saw was attached to it, and why the belt came off when a large slab was sawed rapidly Discussion ensued on how to set up the buzz saw and how to use the first-class lever in lining up the car wheel and the saw wheel Conclusions were drawn that rhythm in work is really an application of inertia, and that farm life offers many possibilities for groups to work together in a rather unique way.

Some conception of the varied types of activities involving scientific principles, as well as an appraisal of the learning taking place, can be gathered from the following comments taken from pupil notebooks

Paula

At Heather Hill Farm there were a number of things going on and I decided to do some carpentering on a floor upstairs in the barn This was grand fun and gave me a feeling of satis faction when I nailed a board down successfully or sawed a board straight It was hard work, but made me work up an appetite for the good supper we had

Ralph

In the afternoon I did a little painting on the garage Then it started to rain so I gave that up I then went in the barn and helped two others put up the second story in the barn. We worked on that most of the afternoon and finally finished Finishing made me feel pretty good

Maressa

We painted the garage after the batons were on We wrecked the chicken coop and handled wood for the saw In other words we really worked

Ken

In wrecking the chicken coop I used a lever with which I was able to pry out nails, lift the whole roof, and move the roof off the walls . . A good example of the variation of the moment of force was that I was able to remove spikes with my wrecking bar which could not be removed with a short handled hammer Later in the morning when I switched to sawing, I saw that the truck had been jacked up by means of another first class lever

Howard

As Mr C . didn't feel very well we did some of his work We actually enjoyed hauling water, feeding a pig and getting and piling wood, after which we settled down to our notes

The group also had experience in the provision and preservation of food for the winter They observed the butchering of a pig, made sausage, prepared ham and bacon, rendered lard, and made soap Pupil notebooks again tell the story

Ruth.

Boiling water was poured into a huge wooden tub In this the pig was placed by means of a pulley Then lye was poured completely over it Again the pig was dipped in boiling water and taken out to be scraped perfectly clean The pig was then hung vertically and slit neatly down the middle The liver was inspected by a government inspector and found to have an inflammation, but we were told that the rest of the meat was still edible The pig was thoroly cleaned and left to hang stiffly in the barn In a day or so it was cut into the following pieces ham, fat back, loin, bacon, spareribs, picnic shoulders, clear plate, Boston butt, fore shank, and jowl

Henry

I saw where they got the pork chops and also where they got the bacon I never knew they could get so much out of a pig

Kenneth

Note how a tripod of three two by fours was made to hold up an end of the pole supporting the kettle In order to lift the pig easily so that it could be put in the lye water, a block and tackle with a mechanical advantage of four had been hung from the rafters In this way a force of 37 5 pounds could lift a 150 pound pig

Short trips were taken to neighboring farms Here pupils saw how farmers kept their animals warm and clean, and how they fed cattle and chickens scientifically They noted the use of sawdust for insulation around houses, the storage of food in cellars, the convenient arrangement of farm buildings, and the use of various mechanical devices such as washing machines and cream separators

A visit was made to a modern Ayrshire dairy farm which produces and retails 300 quarts of milk daily Scientific farming was studied here Pupils saw the caterpillar tractor at work They observed the use of bottling, cooling and

BOILING WATER FOR USE IN BUTCHERING

GROUP WITH TRACTOR

pasteurization equipment They gained some understanding of the adaptation of Ayrshire cattle to hill regions, the use of hay and ensilage as roughage, the endless process of bookkeeping with a registered herd, the hazards of large-scale production and the meaning of the saying, "The value of the herd sire is half that of the herd"

With regard to the trip to a local granite quarry one pupil wrote

> There were two points that stood out as most interesting They were the very simple machines used in all of the processes and the fact that you see the granite as it is in the earth and then all of the processes right then and there until it is shipped to be used as tombstones

At a local woods lumber mill the pupils saw the whole process from felling and hauling trees to the sawing of rough lumber The owner of the mill, an experienced lumber man whose eyes still light up when he surveys an especially fine tree, enjoyed answering the many eager questions Calculations were made on one tree, determining the cost of felling, hauling, sawing and trucking it to the highway There was time to see how each part of the activity was carried on, how the logs were moved on to the carriage, how the carriage was made to go forward and back, how the width of board was determined, how sawdust was blown away, and how board-feet were measured and tallied

Much learning about the relation of trees to soil, flood control and future prosperity was evidenced by pupils in their discussion of the trip

Margaret comments

> As we walked thru the woods we saw a great change in the trees. On our side of the fence there was rich black soil filled with leaf mold Water was plentiful and the smell of decaying and damp leaves was strong Many varieties of mosses and berries grew, such as gold thread,

star moss, travelling and shining club moss, stag moss, laurel, winterberry, and wintergreen On the other side of the fence there wasn't a tree over two inches in diameter The ground was not as fertile and the trees were thin, anemic, and a scrubby third or fourth growth The comparison between the lumbered and the virgin (or relatively so) forests, shows the vital importance of reforestation As an example the mill started in a rich hemlock grove Now they are chopping down tree after tree, young, old, fat, thin, tall or short as long as it makes lumber What will be left of the beautiful hemlock grove? Only a tragic procession of neatly cut stumps will remain to mark the spot Years will roll by, the land, open to wind and water erosion, will be swept by floods and droughts What will become of our green hills? With the trees cut down the soil will be washed away and the towns drowned Trees prevent floods and erosion by controlling the water and holding the soil together. The roots hold the soil and keep it from being washed away The leaves fall and stimulate plant growth and protect the roots in winter

That it is impossible to distinguish clearly between scientific values and social science values when appraising these experiences is shown by two pupils in their attempt to express their reactions to rural study.

Robert

The week was an experience that I shall never forget It not only showed how rural life compares with urban life, but it also brought me very close to the people I wondered when I visited at various places whether the native children realized how much experience they were actually getting by living where they could do work The older people were willing to stay on farms and barely exist The younger people, however, were discontented with that type of life They wanted more out of life and felt that they could earn more money and buy more privileges and luxuries by going to large cities or working in factories that were invading the countryside

Eleanor made this appraisal

I think I could write a book on everything that happened and everything I saw and learned during the week of studying rural life Incidents and things like—the stage that brought the milk, mail, and groceries, the wonderful apples

GROUP AT LUMBER MILL

that you could eat all day, how we pumped water, heating water when you needed it, the building of the fires in the morning in contrast to turning on the radiator in a steam heated apartment, bringing in wood and keeping the fires going, using the lamps instead of electric lights, contacts with people in the community, the stories about buildings, farms, and towns, our discussions, our evenings together, the barn dance—the perfect party evening—the varied activities inside and outside, making bread and nailing slats on the garage, the cider press and how it worked, the mechanical advantage of 720 and the pressure of ten tons applied to squeeze the apples, the animals we saw with the complications of caring for them, our surroundings, the beauty of the valleys and the hills, what our houses and rooms were like, the little window by my bed where every morning I could look out and see the dawning day, the contrasting types of people we met. Such incidents as these and many others I think will remain with us for years to come We now have a realistic idea of rural life which could not be found any other way We worked and played together and got to know each other and that's what made the trip a success We really were one large family.

The enthusiasm of all the pupils and their parents for these experiences indicated their worth Several pupil-initiated projects grew out of these rural studies One group of pupils secured, dismantled and later ran an automobile engine One group continued work on the curing and canning of meats Some pupils investigated the work of hospital clinics and of settlements Some studied the soil and forest conservation work of the United States government Others constructed working models of water wheels and of a lumber mill The intelligent interests of the pupils attest the values they received from rural study The entire class work throughout the remainder of the year was definitely motivated Pupils continually compared and contrasted their in-the-city experiences with those they had had in the country These urban boys and girls had gained a better understanding of how science functions in their daily lives

THE PAN AMERICAN HIGHWAY. II.

By HERBERT C. LANKS
MEXICO CITY, MEXICO

Guatemala

Guatemala is a land of many wonders, steep ascents and descents, volcanoes and volcanic lakes, quaint and picturesque people and the remains of the oldest civilization on this continent. Although Guatemala has a fringe of low-lying, tropical, coastal plain around the higher central plateau, the latter is the cool high Guatemala we think of. Most Indian of all the Central American countries, it has preserved the primitive, picturesque dress of centuries ago.

Guatemala has probably a greater network of highways in proportion to its size than any other Latin American country. Although not generally paved, they are passable and make the various parts of the country accessible to each other all seasons of the year. The very economic life of the country is based on these highways for Guatemala is a coffee country. Since it is too rugged for railways, highways are necessary for getting out the coffee. Every adult male in the country must bear his burden of highway construction financially or by physical labor to the equivalent of two week's work a year.

After crossing the Mexican frontier near Malacatan, the Pan American route climbs in very steep ascents to the eight thousand foot elevation of San Marcos. Neatly paved streets and orderly rows of adobe-walled and red tile-roofed houses characterize such old Indian villages and towns. Neatness and orderliness characterize Guatemala internally and externally in contrast with her Latin American neighbors. Up in this cool, elevated plateau it becomes uncomfortably chilly at night. Even during the day in the shade at this altitude one feels quite chilly.

Along any of the highland roads, land is cultivated on very steep inclines. One wonders how the patient cultivator of the soil maintains his foothold on land with such a precipitous slope. Moisture is furnished often by the light precipitation from the clouds which rest on these steep slopes. Where cultivated fields do not yet take the place of the dense, virgin forest we find in the latter strange and exotic plants. Enormous ferns that seem to belong more to the carboniferous period, wild orchids, gigantic Guanacaste and Ceiba trees, all growing together in an impenetrable jungle, color the exotic scenery along the highland roads of Guatemala. Such is the road with its very steep ascents and descents on the Quezaltenango, second largest city of the country.

One of the interesting side trips for the tourist off the Pan American Highway route is to Chichicastenango, heart of the Quiche-Mayan Indian country. There are many other interesting Indian centers as Totonicapan, Momostenango, Solola and other places. However, market day on Thursdays at Chichicastenango is one of the largest and most picturesque. Also, it is here that the Indians perpetuate a quaint ancient ritual of burning of copal incense in front of and in the Christian churches. The floors of the churches at Chichicastenango are slippery with the wax of lighted candles placed on the floor leading from the entrance to the altar. Flower petals, pine needles and other votive offerings are similarly placed, quaint remnants of a pagan culture of bygone days.

Perhaps as picturesque as anything is the religious procession occurring on almost any saint's day when the image of a saint is carried through the streets on the

THE PAN AMERICAN HIGHWAY
WINDS TORTUOUSLY UP INTO THE MISTY MOUNTAINS TO QUEZALTENANGO IN GUATEMALA NOTE GIGANTIC TREE FERNS STANDING IN CULTIVATED FIELD AT THE LEFT.

shoulders of men or women to the accompaniment of beating drums and shrill fifes with sky-rockets and bombs to accentuate the occasion Besides a most interesting Indian life, the tremendous ascents and descents to highway altitudes above ten thousand feet, the towering volcanic cones, the strange and exotic vegetation and the beautiful emerald blue lakes supply an infinite variety of scenery of unsurpassed beauty and awesome grandeur

The highway crosses the country to the capital from Quezaltenango by several routes, one leading around the beautiful Lake Atitlan Nestled in the folds of the bold mountain slopes which surround this famous lake are Indian villages named after the twelve apostles, some of them only accessible by boat from the lake The highway climbs and twists to the high altitudes surrounding the lake, glimpses of which become suddenly visible through the clouds far below as the motor car swings dizzily around the points leading up to the plateau above

The bleak high altitudes at some points on the road to the capital become uncomfortably cold At length a glorious sight is glimpsed through the pass by which the highway descends to a great valley of warmer climate and greener appearance The sun is reflected on the distant white buildings of a gem set in verdant green setting A welcome sight is this most modern capital city of a country that is essentially primitive in culture All these countries have their contrasts, but Guatemala probably excels in contrasts, with its most primitive of indigenes and most modern of capitals The modernity of its capital is due to the fact that earthquakes have played such a part in shifting Guatemala capitals to new sites Many of the present city's buildings date from the earthquake of 1918 The site of the old colonial capital destroyed by earthquake in 1776, now called Antiqua, is worth a visit Here are seen excellently preserved ruins of the massive structures when the capital city was one of the cultural centers of the new world

To-day Guatemala City is clean, peaceful, quiet and modern, in fact, modernistic in parts The shops, for the most part, would grace any American city Fine movie houses show late-run American and other photoplays There is not the same hustle and bustle of streams of traffic here as in other Central American metropoli of the same size

El Salvador

Salvador is the smallest and the most densely populated (three times the population density of the United States) country of Central America. It has the distinction of being the only republic north of Panama which does not touch two oceans, for it lies entirely on the Pacific side It is served by the most and the best roads of all Central American countries, being traversed nearly the entire length by a modern paved highway

With the exception of Guatemala, Salvador is the only other Central American country that has transportation across its frontier into another country, and that country is Guatemala From the latter country, Salvador can be entered by highway or railway, although this has only been possible in the past several years The railway from Salvador across the Guatemalan border was built more to reach the Guatemalan point of Barrios on the Atlantic side, rather than for transportation into Guatemala As a matter of fact, the Central American countries have little commercial intercourse with one other Their foreign trade is with other and remote countries, primarily because their exports are similar.

The two hundred miles across the country of Salvador are an interesting stretch of the Pan American Highway The first large place in Salvador out of Guatemala is Santa Ana, of about 80,000 population, a center for the cultivation of high-grade coffee It is only 48 miles from the capital, San Salvador, reached by paved road which is part of the international route Roads and railway lead out from Santa Ana to various points of interest, including several of the lakes which make Salvador's scenery so interesting Only a few hours south by highway near Sonsonate is the famous Mount Ixalco, which is constantly active It is referred to as the "Beacon of the Pacific," because its red glow is visible

GUICHE–MAYAN MAIDEN WEAVING ON THE HAND LOOM OF HER ANCESTORS

INDIAN WOMEN AND CHILDREN ON A WELL-PAVED STREET IN GUATEMALA
EVEN LITTLE CHILDREN ADOPT THE CUSTOMS AND DRESS OF ADULTS

A YOUNG INDIAN GIRL ALONG THE WAYSIDE IN GUATEMALA
CALMLY UNDOES HER BURDEN AND PREPARES HER MEAL

at night far out on the Pacific The highway from Santa Ana to the capital passes through Santa Tecla, where one can visit the huge crater within a crater

San Salvador is the capital city of about 100,000 population Its elevation of 2,000 feet gives it a semi-tropical climate, warm, but not unpleasant It is a modern city with a style of architecture that would suffer least damage from earthquakes It has beautiful parks with luxuriant tropical plants and blooms Considerable English is spoken in the capital and Americans are most warmly received The democratic nature of the people makes them seem to have much in common with Americans

The highway from the capital southeast to the border of Honduras is about completed as far as San Miguel, which is only 25 miles from the border The country is rolling from the capital southward, with ascents and descents, although nothing like the ascent to the high central plateaus of Mexico, Guatemala and Costa Rica The road passes through a coffee country noted for its beautiful scenery There are rivers, lakes and tropical landscapes offering constant variety to the scenery enroute The large Lempa River, at present, is crossed by ferry Along the coast are found the only extensive forests of Peruvian balsam in the world Near San Miguel to the south, the highway passes through some extensive fields of henquen, or sisal fiber

The Pan American Highway leaves San Miguel somewhat to the northeastward, and crosses the Guascoran River, which is the frontier between Salvador and Honduras, near Santa Rosa This stretch of the international route is as yet not much more than a dirt trail, passable only in the dry season

Honduras

Less than 100 miles of the Pan American Highway passes through Honduras It is the only country through whose capital the international route does not pass, because to do so would require a considerable detour There is, however, a branch that leads from San Lorenzo up to

THE CHURCH OF AMAPALA
PERCHED ON A HILL OVERLOOKING THE TOWN

MOTHER AND CHILD IN GUATEMALA.

A MULETEER SECURES HIS LOAD

the capital, Tegucigalpa The route of the Pan American Highway crosses the Guascoran River near El Aceituno and from thence continues to San Lorenzo and to Choluteco At the latter place, a very fine bridge contributed by the United States crosses the river Only earth-roads exist to these places, possibly passable with great difficulty by motor in the dry season From Choluteca, which is not very far from the Nicaraguan border, the route crosses a slightly developed region into the region of Esteli of Nicaragua, which is just as slightly developed

Honduras is the third largest of the Central American republics with about a million population, very slightly connected by any means of transportation The country is mountainous, abounding in minerals and richly timbered but very little developed Relatively speaking, Honduras depends more upon air transportation than any other Central country. Tegucigalpa has the best aviation field in Central America, well served by two large air lines, Pan American Grace and Taca

A good deal of Honduras is unexploited and even unexplored Probably no Central American country could profit more from the coming of a modern highway At present it is easier to go around the short stretch of highway through Honduras by means of a motor launch across the Gulf of Fonseca into Nicaragua From the port of Moragan it is but a short distance by rail or horseback to Chinandega, which is the first large place on the old route of the Pan American Highway in Nicaragua The train parallels the route up to the capital, Managua Because of this fact the international route has been changed at the request of the Nicaraguan government to approach the capital from the east of Lake Managua

Nicaragua

The Pan American Highway has been re-routed through northern Nicaragua Formerly it passed west and south of

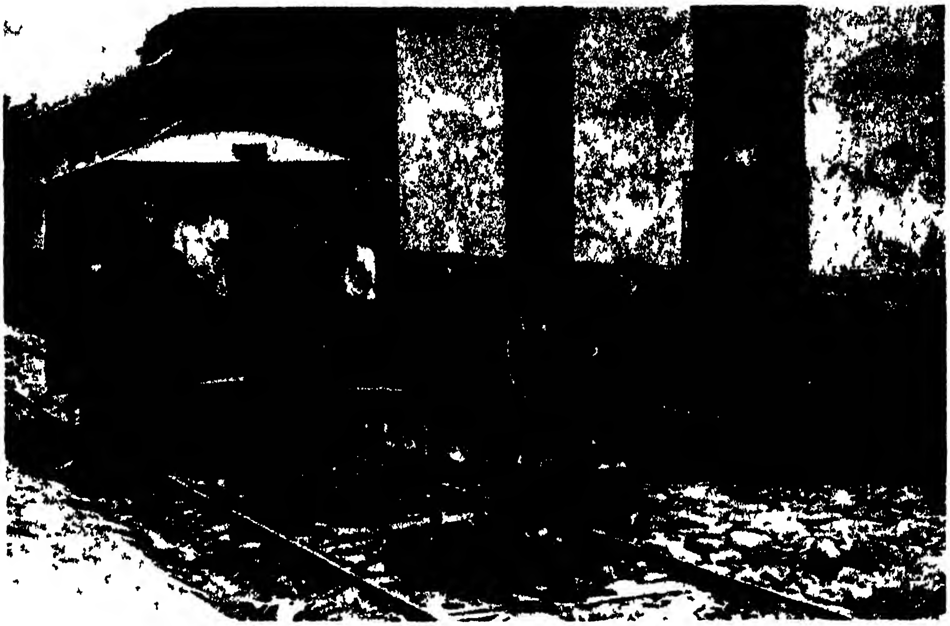
Lake Managua, but now passes between Lake Nicaragua and Lake Managua, to the east of the latter. This takes the international route through a large undeveloped region in Nicaragua centering around Matagalpa. The original route skirted the Gulf of Fonseca and paralleled the railway from Chinandega to the capital, Managua Since this region was already served by this railroad, it was thought by the Government of Nicaragua that the projected highway would do better to serve the rich but little developed region further inland.

From Managua the highway reaches the old colonial city of Granada, on Lake Nicaragua, follows more or less the western edge of the lake over fairly level country to Rivas, approaching the border of Costa Rica As the latter border is neared, the country becomes rougher and more rugged, as is typical of Costa Rican topography

Very little of this route through Nicaragua described above is finished highway Leading out of the capital, improved road is being pushed into surrounding country This is the general story of highway development in all these countries Generally speaking, the capital is the economic, as well as the political, capital Hence, highway development in most of these countries develops first as a series of roads leading from the capital to centers which serve and are served by the capital. At present the highway in Nicaragua is being most actively pushed northward between the lakes toward the border of Honduras into the Matagalpa section Its furthest extent at present is about 40 miles up to the Maderas bridge, which is a gift of the United States to this country A very rough all-weather road reaches as far as Esteli toward the Hondurean border

Nicaragua is the largest Central American country and the most sparsely populated at the same time Crossed by two heavy mountain ranges the country is considerably broken up in topography with also resultant climatic differences

THE PAN AMERICAN HIGHWAY ALONG LAKE ATITLAN.
PRESENTING A MOST PICTURESQUE SIGHT WITH THE VOLCANO OF SANTA MARIA IN THE BACKGROUND



A HORSE-CAR IN A VILLAGE IN SALVADOR

THE CHARM OF VISITING THESE COUNTRIES LIES IN THE FACT THAT ONE STEPS BACKWARD A COUPLE OF GENERATIONS IN SOME THINGS SUCH AS THIS, A CENTURY OR TWO INTO COLONIAL ARCHITECTURE AND CUSTOMS, AND A MILLENNIUM IN ANCIENT INDIAN ARCHEOLOGICAL RUINS

NATIVES FROM THE COUNTRY SELLING FOOD IN TEGUCIGALPA, HONDURAS

Very large sections are absolutely undeveloped and even little known Like all Central American countries, the large population centers are on the Pacific side, much of the area of which is occupied by the large lakes Managua and Nicaragua. The latter comprises part of the route of the proposed Nicaraguan canal, the rights of which are owned by the United States through a treaty of 1916 Wonderfully fertile regions, both valley and plateau, would be thrown open for use if Nicaragua could develop any system of transportation

AN AERIAL VIEW OF TEGUCIGALPA, CAPITAL OF HONDURAS

Costa Rica

At present, the Pan American Highway route is most impassable in Costa Rica because of the extreme ruggedness of the terrain and the sparse population In addition to the broken topography with very high altitudes, the international route crosses sixty streams that will have to be bridged It is very unlikely that the Costa Ricans will be able to complete their stretch of the highway in the near future without some outside assistance With regard to highway development, especially along the international route, Costa Rica repeats the same story as do the other countries, that is, a system of highways reaching out from the capital Only about 50 miles of Costa Rica's 356 miles of the Pan American Highway are at present paved The 163 miles from the Nicaraguan border to Naranjo is but dirt trail, passable in some places in the dry season by motor, but it is not real highway A slightly less amount remains to be completed from the town of Cartago to the Panama line The 145 miles of this section will probably be the most difficult stretch in the whole Pan American route, for the road must either ascend to an altitude of over 10,000 feet or else bridge innumerable streams flowing down between the mountain folds

The ruggedness of Costa Rica is an asset, as well as a liability, for probably no other Central American country, except Guatemala, offers tourists such a variety of scenic attractions Two active volcanic craters are accessible not far from

the capital, San Jose The government is completing a concrete highway up to one crater, Irazu In addition to unusual scenery, Costa Rica offers its capital, San Jose, as one of the most delightful stopping places along the international route in Central America Besides its ideal climate at slightly less than 4,000 feet elevation, San Jose preserves its early colonial tradition of being the cultural center of Central America As Guatemala is the most Indian of the republics, so Costa Rica has the purest Spanish blood of the Central American republics

TYPICAL LANDSCAPE ON A HIGH CENTRAL PLATEAU IN COSTA RICA

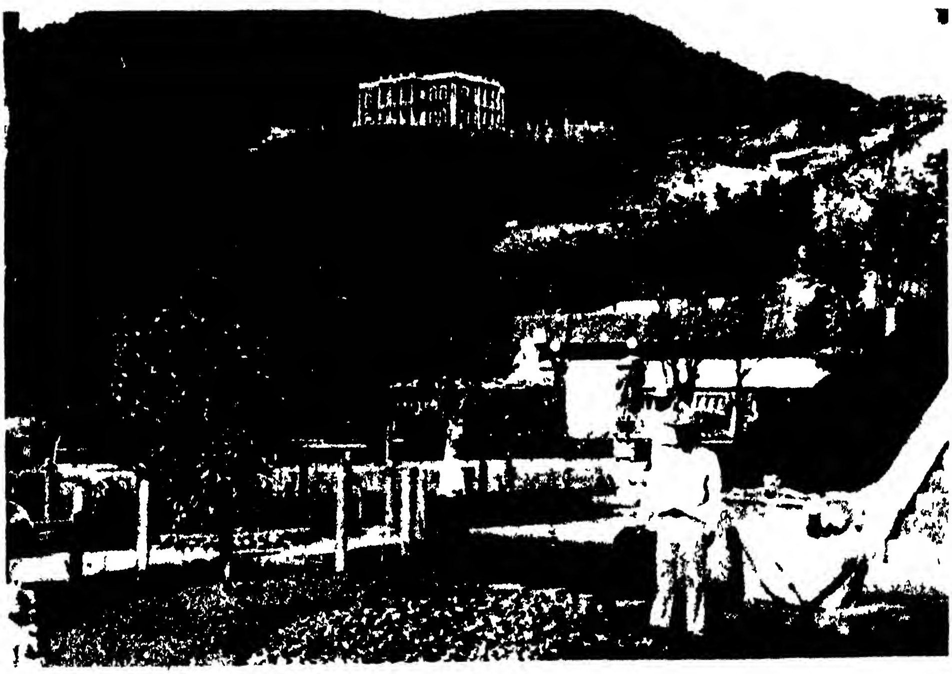
Panama

The country of Panama has the longest section of the Pan American Highway route in Central America and also the longest completed section Of the 367 miles of the international route that passes through this country, over 300 miles are improved, over 200 miles being paved Less than the 50 miles near the Costa Rican line remains to be graded. The highway, of course, needs much improvement to be made first class It becomes increasingly better as we go south to Panama City From the latter capital city modern road building machinery is laying concrete northward. Many old one-way bridges along the route are being replaced by modern two-way structures The modern suspension bridge across the Chiriqui, below David, is a gift of the United States to this country Panama has less severe grades along its route of the Pan American system than any other country along the way Like in all the other countries the highway keeps to the Pacific side, in places passing within sight of the Pacific Ocean At the same time, it passes through most of the large centers of the country

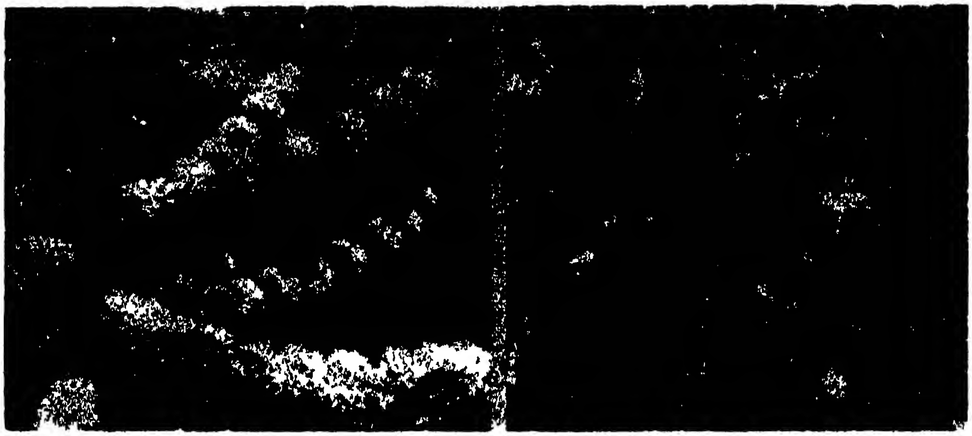
With the great number of employees and members of the Army and Navy and of the Canal Zone a little America has been made in the tropics All the resources of a higher standard of cultural and social living are available here, so that Panama is one of the most attractive places in the tropics for American tourists Many Americans, pensioned off from service in the Canal Zone, continue to live on estates developed by themselves in the country As this continues, the country will become increasingly at-

MAKING ROPE FROM A CUBUYA FIBER IN COSTA RICA

WITH A PRIMITIVE TOOL. THE LOOSE BOW MANIPULATED BY THE BOY IMPARTS THE TWISTING MOTION NECESSARY



A HOSPITAL ON A HILL OVERLOOKING A PARK IN TEGUCIGALPA, HONDURAS



THE COFFEE TREE IN COSTA RICA
THE BLOSSOMS AND THE BERRIES OF THE COFFEE TREE

tractive as a Mecca for tourists from all countries It is very possible for Panama to become a great Riviera, attracting pleasure seekers from all over the world Surely it will become a great Mecca for American tourists as soon as the Pan American Highway is opened through Mexico and all Central America Then, the great middle class American tourist can experience foreign travel and comfortable adventure from his own car over the 3,305 miles from the American border to the Canal A constant stream of human and freight traffic will, within a few years, be passing overland through strange and interesting lands that con-

DRYING COFFEE IN COSTA RICA
AFTER COFFEE IS PICKED IT MUST HAVE AN OUTER PULP AND INNER SKIN REMOVED THIS IS DONE BY MEANS OF A PULP MASHING MACHINE AND WASHING THE BERRIES IN MOVING WATER. THEN THE BERRIES ARE DRIED IN THE SUN ON LARGE FLAT AREAS, GENERALLY OF CONCRETE, AND THIS BECOMES THE COFFEE OF COMMERCE COSTA RICA PRODUCES SOME OF THE FINEST COFFEE

nect the two Americas; the dream of great statesmen of both Latin and Saxon America, Bolivar, Clay, Blaine and others, will then be accomplished.

History of the Inter-American Highway Route

At the Fifth International Conference of American States in April, 1923, at Santiago, Chile, delegates from nineteen American republics, with the United States, passed a resolution calling for a conference on highways to study measures for a program of highways within and between the different American countries Under the leadership of the Pan American Union, a Latin American Highway Commission from all countries toured and inspected the highway systems in many states of the United States in June, 1924 The First Pan American Congress of Highways was called for October 3–13, 1925, at Buenos Aires This was followed by other tours of Latin American journalists and business men over American highways, mainly under the auspices of organs of the Pan American Union

At the Sixth International Conference of American States, at Habana, Cuba, in January and February of 1928, a resolution was adopted calling on the Pan American Congress of Highways of Rio de Janeiro, in July, 1928, to consider and adopt agreements on the construction of a road of longitudinal communication across the continent Meanwhile, the Cole bill, March 26, 1930 (H J Res No 355, 70th Congress of the United States) was passed authorizing the appropriation of $50,000 to cooperate with the members of the Pan American Union in furthering the building of an Inter-American Highway.

At the Second Pan American Congress of Highways at Rio de Janeiro, from August 16 to 31, 1929, several important conclusions were reached to facilitate the development of inter-American highway systems Among these conclusions were · that each state should make a study of its own highway system plan and where it could connect up with adjoining states, that a continuous and uninterrupted program should be adhered to, that a uniform code of signs and directions be prepared for adoption

The first Inter-American Congress of only states of Central and North America was held at Panama, from October 7 to 12, 1929 This group planned an Inter-American Highway Commission to study a possible route and costs The United States Congress provided for the American participation in this commission of authority in March and June, 1930, and the president of Panama called the whole Inter-American Commission to meet in Panama in March, 1931 Field reconnaissance had already started in September, 1930, in Panama, and in October, 1930, in Honduras under the United States Congressional appropriation act of March 26, 1930 March and April, 1931, saw field reconnaissance begin in Guatemala and Costa Rica, respectively, and in January and December, 1932, in El Salvador and Nicaragua, respectively By May, 1933, all engineers had completed their field work The printed report, entitled "Proposed Inter-American Highway," was released in March, 1934

This Reconnaissance Survey of the Inter-American Highway[1] (Senate Document No 224, as it is generally referred to) establishes a roughly surveyed line of a highway from the border of the United States to the Panama Canal with the cooperation and approval of the countries through which it passes Since Mexico has for some time planned, and is putting into execution, her length of this proposed Inter-American Highway, it is not necessary for the report to give much attention to aiding that country.

[1] The Inter American is that part of the Pan American route down to Panama.

OX-CARTS IN COSTA RICA
ARE A VERY IMPORTANT MEANS OF TRANSPORTATION ON THE DIRT ROADS IN THE COUNTRY

In the other countries, that is, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica and Panama, it does establish a surveyed route This might be shifted somewhat from time to time as the several countries consider other factors more seriously and as the present construction actually takes shape Yet, in a general way, it does offer the most reasonable and satisfactory route for an Inter-American Highway route to all concerned.

NOTE All photographs were taken by the author

WRINKLES OF ASIA

A STUDY OF MOUNTAIN RANGES

By BAILEY WILLIS

EMERITUS PROFESSOR OF GEOLOGY, STANFORD UNIVERSITY

ARE the wrinkles on our face there because the muscles have pushed or because the flesh has shrunk or the skin has expanded? There is nothing personal in the question, I assure you I am merely applying the scientific method of multiple hypotheses to the problem of wrinkling, having in mind the wrinkles on the face of Mother Earth and more particularly those on the continent of Asia They are mountain ranges, you know, and they may perhaps be explained by either one of the three effects I have indicated, that is, because the continent has been pushed or the globe has shrunk or some part of the outer crust has expanded Geologists familiar with current theories of mountain building will recognize the reference to the speculations regarding Continental Drift and the pushing up of a frontal wave, so to speak, the Andes of South America, for example, and they will recall the old Theory of Contraction of the crust of a cooling globe, but they may not have run across the idea of elongation of crystals and consequent expansion of considerable areas, as suggested by the hypothesis of Metamorphic Orogeny or mountain genesis by metamorphism It seems to me worthy of consideration, and since it is not so well known, I propose to present it by testing its ability to account for the wrinkles of Asia

The surface of Asia may be compared to a bas-relief. The background is the vast expanse of plains and plateaus The raised pattern is a design of mountain ranges The background itself is neither flat nor level Some areas lie low, close to sea level, as do the plains of eastern China and of Siberia, including Russia Others stand high: the plateaus of Tibet, Mongolia, and Peninsular India The pattern of mountain ranges is raised above the plateaus in a degree comparable with great mountains in Europe and the Americas, 5,000 to 15,000 feet; but where the plateaus themselves are high the ridges and peaks that stand upon them are preeminent in altitude above sea level, the highest mountains in the world Who does not know Mt Everest, the supreme peak, whose summit rising to 29,002 feet has thus far defied the most intrepid of mountaineers?

When we look at a work of art, a finished bas-relief, we know that the surface was different before it was sculptured So it is with Asia The present landscape is a result of prolonged sculpture by heat and cold (which disintegrate rocks), and by wind and water (which scour off and wash away detritus) The effect of these ceaseless activities in the long, long run is to wear down any height of land to a graded plain, sloping gently to the sea, but before that ultimate result is accomplished the scene passes through a prolonged stage during which valleys widen and heights of harder rock survive as residual ridges and knobs That is the condition of the plateaus of Asia, in general. It is doubtful if the continent has ever stood at a constant level long enough to have become completely graded Certainly it is not now so steady The plateaus whose wide expanses were

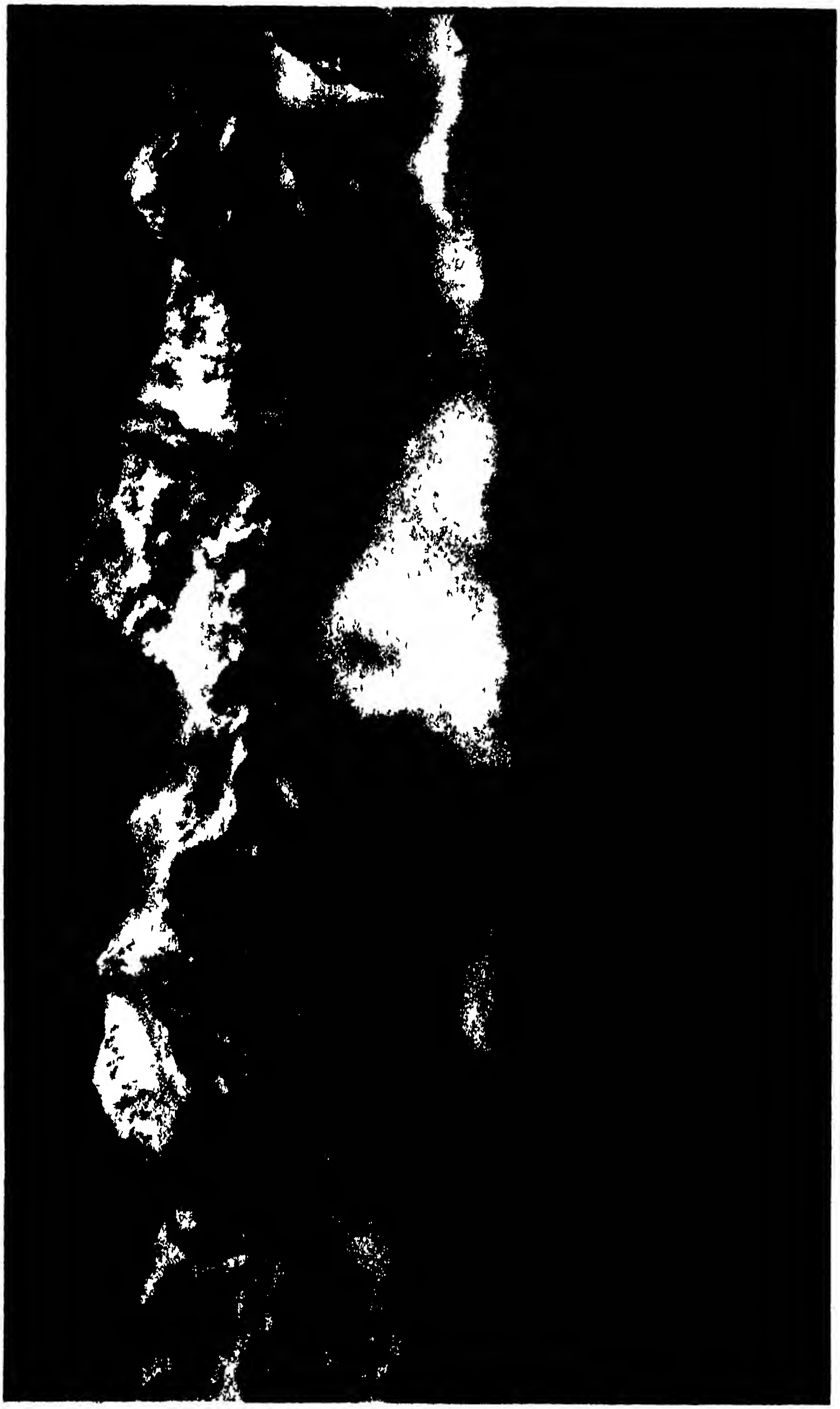


FIG 1. KANCHANJANGA (KINCHINJUNGA) OF THE HIMALAYAS PHOTOGRAPHED FROM DARJEELING, SIXTY MILES AWAY ALTITUDE 28,140 FEET.

graded when they sloped gently to the sea have recently been elevated high above that position and consequently are being deeply carved by the sawing rivers. Nowhere are there younger, more terrifically abyssal canyons than in Asia Their precipitous walls, in places ten thousand feet high, demonstrate the recency of the lifting action, which in spite of gravity has raised the plateaus to great altitudes What is the force that is stronger than gravity?

Thus the background of the bas-relief of Asia puts a question But what of the pattern of mountain ranges? They too have been elevated, and not simply pushed *up* but also pushed *together* Each range is a zone of squeezed rock that has been compressed horizontally Let us consider the mechanical effect for a moment

The rocks, though some are massive like granite, are in large part bedded, they consist of strata, which were laid down in flat layers and accumulated to form piles of strata many thousands of feet thick Much of the sand and mud was thus deposited beneath the sea, as is shown by the marine fossils they contain Now a pile of layers, even of rock layers, can be bent, if sufficient pressure be applied, and beds of sandstone, mudstone and limestone can be bent without cracking, provided they be so loaded that the squeeze holds the rock substance firmly together That idea, that a sufficient load can control fracture and prevent it, was first clearly stated by Albert Heim, the great Swiss geologist, who grasped it as he examined the arches of strata in the Jura and the Alps. But I think the canny Scot, Sir James Hall, must have realized it when, as long ago as 1797, he laid a heavy door on a thick table cloth and pushed the cloth into folds under the door in an effort to simulate the folds he had observed in strata on the coast He had the idea of folds all right, but perhaps he did not understand that the effect of the load is to hold the beds together on top of each arch so that they slide past each other on the legs of the structure as they accommodate themselves to the shortening and lengthening of the curves on the inside and outside, respectively Accommodation by sliding is an essential condition of bending without breaking Where it can not occur, as in massive rocks like granite, the body yields by shearing into more or less squarish blocks These details of structure are to be seen in all mountain ranges, and they demonstrate the action of a horizontal force of compression The mountains of Asia are no exception They have been intensely squeezed What can be the origin of a pressure adequate to fold and shear through thousands of feet of rigid rock, shortening the zone by many miles and forcing mountains to stupendous heights? That is another question that is put by the wrinkles of Asia

There are really three questions: (1) What is the force that lifts plains to the altitudes of plateaus, against gravity; (2) What is the force that acts in a horizontal direction in the earth's skin and produces wrinkles which are mountain ranges, and (3) What is the relation, if any, between the two processes?

These are not new questions They have been posed repeatedly during the past century and a half and many able thinkers have tried to answer them Yet there is to-day no general agreement regarding a solution, and skepticism is a common attitude among the best informed I may, perhaps, state my own position, without offending It seems to me that the current theories regarding the causes of movements in the earth's crust may be divided into two general classes, namely, those which are purely speculative and those which were framed with less knowledge of geology and physics than we now possess. I can not

accept a gossamer spiderweb of suggestions as the basis of a sound theory, no matter how plausibly the hypothesis may explain certain puzzling phenomena The Theory of Continental Drift is an example in point Nor can I think it reasonable to maintain a theory which is based upon concepts of the earth's constitution and history that, though once generally accepted, are now known to have been mistaken. The Contraction Theory is the best known among those of that class

In theorizing we can not do better, as it seems to me, than to follow the example of T C Chamberlin, who together with G. K Gilbert originated the method of *multiple* hypotheses He described three methods of mental procedure the method of the ruling hypothesis, the method of the working theory, and the method of multiple working hypotheses [1] In discussing their places in the history of scientific investigation he says in part

> The method of the ruling theory occupied a chief place during the infancy of investigation It is an expression of a more or less infantile condition of mind I believe it is an accepted generalization that in the earlier stages of development the feelings and impulses are relatively stronger than in later stages

Regarding the second method, he says

> The method of the working hypothesis differs from the ruling theory in that it is used as a means of determining facts rather than as a proposition to be established It has as its chief function the suggestion and guidance of lines of inquiry, the inquiry being made, not for the sake of the hypothesis, but for the sake of the facts and their elucidation The hypothesis is a mode rather than an end

He then points out the danger that a working hypothesis easily becomes the ruling hypothesis and suggests that the defense lies in making a determined effort

> to bring up into view every rational explanation of the phenomenon in hand and to develop every tenable hypothesis relative to its nature, cause or origin, and to give to all of these as impartially as possible a working form and a due place in the investigation.

[1] "The Method of Multiple Hypotheses," *Jour. of Geol*, Vol. V, 1897

Chamberlin practiced the method of multiple hypotheses conscientiously throughout his prolonged researches in cosmogony. Toward the close of his career, after thoroughly reviewing and revising the Planetesimal Theory, which in the latest form that he was able to reach is stated in "Two Solar Families," he said to me

> For twenty five years I have tested every hypothesis of the genesis of the earth of which I could learn or which I could conceive One and one only has withstood every critical test. Do you think I am perhaps justified in thinking it probably true?

The method of multiple hypotheses has been for me a difficult, though salutary discipline It is difficult for me to follow more than one line of thought closely at any one time and in pursuing a selected hypothesis from inference to inference I find myself off on that one track, out of touch with alternatives Yet one has to choose, and sometimes the choice leads definitely in one direction For example In studying any problem relating to movements of the earth's crust it soon becomes necessary to consider the subterrane beneath it What is its condition, molten or solid? What are the pressures and temperatures at any depth and how do they vary in depth? How does the material react to them if they vary locally?, etc

In general it appears to be established that the outer crust or skin upon which we live and which is cold and rigid passes into hotter material below and at a depth of some thirty miles, more or less, reaches a temperature close to the melting point But it is not molten, as I understand the term, for it is elastic (since it transmits elastic, earthquake vibrations) On that evidence the material is elastic to a depth of about 1,800 miles and a shell of that

thickness, which is nearly half the radius of the globe, is distinguished from the central sphere or core, which is relatively inelastic If we call the eighteen hundred mile thick shell the *mantle*, as some do, we may say that the earth consists of the rigid crust, the elastic mantle and the inelastic core.

Every one will agree that the crust is solid, because we observe that it has the qualities of rigidity, strength and elasticity which characterize that state But is the mantle solid? If we answer yes, as it seems we should, since elasticity of shape is a typical characteristic of solids, we have to qualify the definition by recognizing that a solid may be plastic and may move like a viscous fluid if it be so confined that it can not break apart Then, if pushed by a sufficient pressure, it will flow Lead is made to flow through an aperture in making pipe and so is steel in pressing sheets of it into the shapes of automobile bodies Rocks of the mantle of the earth flow in a similar manner under like conditions of a load greater than they can bear without lateral support and of a directed force that is adequate to move them Yet even as the lead and steel are solid, so the mantle may be regarded as solid, though plastic

A plastic solid seems peculiar because we are not familiar with the condition of excessive confining pressure There is another characteristic of solids with which we are even less commonly acquainted, and that is *fatigue* We all know how it feels when a muscle gets tired, when its nervous energy is exhausted and it relaxes Something similar occurs in metals and other substances. For instance, steel tapes, 500 feet long, were once hung in the Washington Monument and stretched by a slight weight If the weight was removed they shortened elastically to their original length; that is at first; but after some months they could not recover; the steel had become fatigued A more familiar illustration of the same property may be noted when a stick of sealing wax is held out horizontally while fixed at one end It will support its own weight rigidly for a time, but will eventually sag down The atomic forces which had held the steel or the wax to a rigid form eventually yield to the persistent stress, slight though it be, and the solid suffers a strain from which it can no longer recover by elastic rebound

Fatigue is thus seen to be a question of *time* We may say that fatigue is a condition to which solids and liquids both are liable, but with this distinction in a perfect liquid fatigue is instantaneous, in a perfect solid it ensues only after the lapse of infinity You ask. Are there such substances? I think we may say yes There are many, well-known liquids that yield at once, and a granite which has maintained crystalline texture for two billion years might be cited as an example of the perfect solid Perfection, however, is rare and impermanent in the material world, and many substances may be regarded as solid or liquid, according to the manner in which they resist for a shorter or longer time, under different kinds of stress

Returning from this excursion into generalities to the question, Is the mantle solid?, we might compare the rocks of which it consists with granite and other assemblies of crystalline minerals and take the affirmative on the ground that its substance is elastic and does not show evidence of fatigue after an indefinite lapse of time. It seems as though that position were sound Yet it is not the last word, for there are materials, such as glass, which are elastic and will yield to slight stresses in due course of time; they may, therefore, be classed as liquids To the extent that glassy rock may constitute a part or the whole of the mantle, it might be considered a kind of liquid

with regard to its resistance to persistent pressure, however slight, although it reacts like a solid, elastically to sharp shocks.

It has been necessary to clear up this question of the solid or liquid state of the mantle, because no one knows surely how much of it may be crystalline or glassy and the uncertainty fixes the parting of the ways for two different hypotheses. The one postulates a predominately crystalline mantle, 1,800 miles thick, the other assumes the presence of a glassy shell of notable thickness in the crystalline mantle. The former is obliged to consider the mantle very strong; the latter can appeal to relatively slight forces to cause great movements in the course of geologic ages

Pursuing the method of multiple hypotheses we can not arbitrarily set either of these alternatives aside as negligible unless we can disprove it, no matter how incredulous we may be regarding its value Definite proof of strength or weakness in the mantle is not now possible; therefore both hypotheses must remain on the list of possibilities. And yet it is not practicable to carry both of them simultaneously in mind through the maze of natural phenomena we must explore in seeking the solution of such a problem as that of mountain growth We stand at the forks of the path, and we must choose either the right hand or the left for immediate exploration; but we may not forget to return sooner or later to see where the other leads, unless others have adequately explored it

We will for the present take the right-hand fork, which leads into the strong, crystalline mantle The alternative of a glassy shell is meantime being examined by Professor R. A Daly and his students of Harvard

The first question relates to energy If the mantle is solid we must show that great forces can be brought to bear to overcome the resistances. Gravity, to which geologists are accustomed to appeal for help, is quite incompetent It may work if adequately disturbed, but it can not start from a balanced condition Heat is a powerful stimulant, but it also is balanced if it is symmetrically distributed. One of the common notions about the globe is that it is cold at the surface and very hot inside and grows hotter and hotter as the core is approached The idea is that at any given depth we would encounter the same temperature, no matter from what point on the surface we started The same picture is presented by the so-called shells of the globe Geologists discuss an outer granite shell, beneath which there may occur in succession a basalt shell, a peridotite shell and possibly others of still denser, heavier rock Various physical characters, such as density, elasticity, etc., are thought to be arranged in definite shells, giving the globe a stratified structure The idea springs from the assumption of a once completely molten globe, in which the materials were sorted by gravity, so that the heavier substances sank toward the bottom, while lighter ones rose to higher levels It implies that the stratification was not materially disturbed by any boiling of the huge mass and that there has been little or no change in the internal structure during subsequent geologic ages No one can say that it is not a true picture, but there is an alternative The materials of the globe may be distributed more or less heterogeneously, they may be hotter or cooler at the same depth along different radii, they may be solid in general and yet melted in places in the mantle, and the related physical characteristics may be irregularly variable. Here then are again two paths to pursue, the homogeneous or the heterogeneous Since we can not offhand prove either of them wrong we must retain both of them in mind, while we

FIG 2 CRYSTALLINE STRUCTURES, GRANULAR AND LAMINATED.
THE GRANULAR TYPE FORMS WHEN THE ROCK CRYSTALLIZES FROM A MOLTEN CONDITION, UNDER HYDROSTATIC PRESSURES THE LAMINATED TYPE DEVELOPS WHEN THE GRANULAR ROCK RECRYSTALLIZES WITHOUT HAVING BEEN REMELTED, AS A SOLID, UNDER UNEQUAL PRESSURES IT IS THEN SAID TO BE METAMORPHOSED

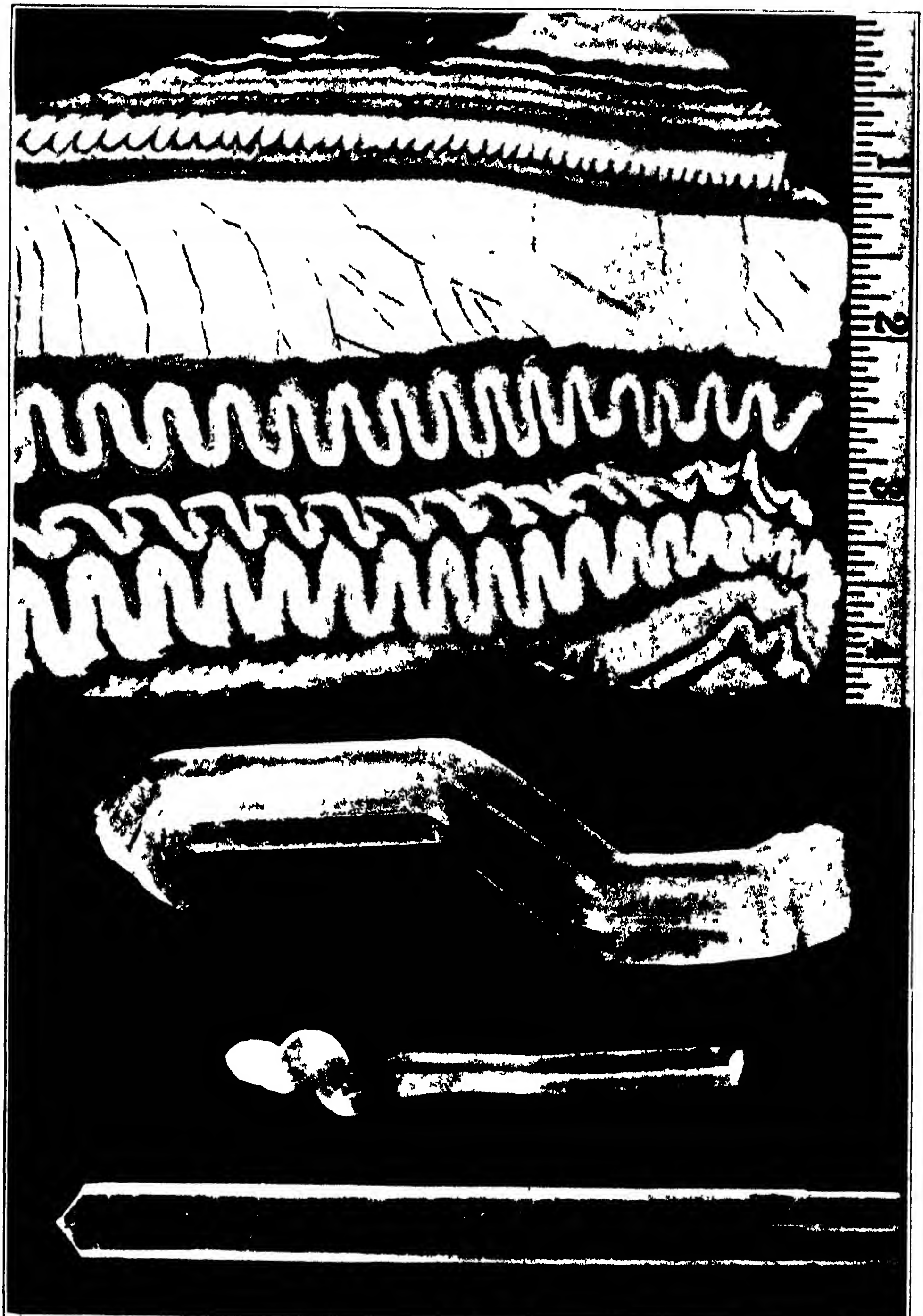

2
3
4

FIG 3 THE POWER OF CRYSTALS IN PROCESS OF FORMATION

Top THE WHITE MINERAL (GYPSUM) REQUIRED MORE ROOM THAN ITS PARENT (ANHYDRITE) AND TOOK IT BY FOLDING UP AND LIFTING THE LOAD *Middle.* THE TWO CRYSTALS OF GYPSUM DEVELOPED IN CONFINEMENT AND WERE FORCED TO BEND AS THEY GREW AGAINST AN IMMOVABLE BODY *Bottom* A STRAIGHT CRYSTAL OF GYPSUM, WHICH GREW FREELY

Effect of Increase in Volume in Solid Rock

THE UPPER SPECIMEN ILLUSTRATED IN FIG 3 CONSISTS OF GYPSUM, THE HYDRATED CALCIUM SULPHATE, $CaSO_4 + 2H_2O$ IT WAS ORIGINALLY THE MINERAL ANHYDRITE, CALCIUM SULPHATE, $CaSO_4$, WITHOUT WATER IN COMBINING WITH WATER EACH MOLECULE INCREASED IN SIZE IN APPROXIMATELY THE PROPORTION OF 3 TO 4 THE SWELLING CRYSTALS DEMANDED SPACE AND TOOK IT BY LIFTING THE LOAD. THE PROCESS APPEARS TO HAVE BEEN SOMEWHAT AS FOLLOWS

ORIGINALLY THE ANHYDRITE WAS PRECIPITATED FROM SOLUTION IN A BODY OF WATER AND ACCUMULATED AS SEDIMENT IN FLAT LAYERS ON THE BOTTOM THE PRECIPITATION WAS INTERRUPTED FROM TIME TO TIME AND LAMINAE OF DARK COLORED CLAY WERE DEPOSITED, SEPARATING THE WHITE LAYERS OF ANHYDRITE IN THE SUBSEQUENT CHANGES THE CLAY REMAINED PASSIVE, BUT AFFORDED GLIDING SURFACES FOR THE ANHYDRITE

AS IT COMBINED WITH WATER EACH CRYSTAL OF ANHYDRITE CHANGED FROM SQUARISH TO FLAT ELONGATED FORMS OF GYPSUM AND FORCIBLY TOOK ADDITIONAL SPACE, PUSHING OTHER CRYSTALS AWAY IF, AS MAY BE ASSUMED, THE ACTION WAS MORE INTENSE OR BEGAN EARLIER AROUND CERTAIN FOCI, THE MUTUAL PRESSURES OF ADJACENT CRYSTALS WOULD ADD UP RADIALLY OUTWARD FROM ANY SUCH POINT OR LINE AND THE EXPANSION WOULD BE LIKE THAT OF A GROWING SPROUT WHEN THE SUM OF PRESSURES IN A LINE OF CRYSTALS INCREASED TILL IT COULD LIFT THE LOAD AN ARCH BEGAN TO FORM AND IT ROSE PROGRESSIVELY, THOUGH PROBABLY A NUMBER WERE GROWING NEARLY SIMULTANEOUSLY SINCE THE SWELLING WAS GENERAL THE LENGTH OF ANY FOLD (TWICE THE HEIGHT OF THE CLOSED ARCH) WAS DETERMINED BY THE STRENGTH OF THE LAYER AS AN ARCH IN RELATION TO THE LOAD AND AS MODIFIED BY FRICTION THE THICKER THE LAYER OR THE LESS THE LOAD, THE LARGER THE ARCH OR FOLD

THE LAYER WHICH COULD NOT FOLD EASILY BECAUSE IT WAS TOO THICK, YIELDED BY SHEARING BEFORE IT COULD ARCH UP, AND THE FRACTURES ASSUMED VARIOUS ATTITUDES ACCORDING TO THE INTERNAL STRESSES BUT THEY INDICATE A PUSH FROM RIGHT TO LEFT AS DO THE OVERTHRUSTS IN THE LAYER BELOW

THE FORCES THAT DID THIS WORK WERE THE ATOMIC FORCES, WITH WHICH 2 MOLECULES OF WATER COMBINED WITH EACH MOLECULE OF THE SULPHATE THEY PRODUCED THE COMBINATION WITH INCREASE OF VOLUME IN SPITE OF THE CONFINEMENT IN THE SOLID ROCK AND AGAINST THE FORCE OF GRAVITY

follow one or the other to its logical conclusions by testing it against some array of facts. In this case I propose to take the path of investigation that leads into the solid, *heterogeneous* mantle.

We start from the observation that the crust is very heterogeneous; it is made up of many kinds of rocks, which are very irregularly distributed. Furthermore, rocks of one and the same composition and character are of very different ages; there are granites that are one or even two billion years old and there are granites which are surprisingly young; the same is true of basalts and other kinds of rock. There never has been a time when the crust was not heterogeneous or was not made up of older and younger erupted masses. What we now assume is that the mantle resembles the crust in the irregular distribution of materials and temperatures, and always has done so.

All right We now have under consideration a heterogeneous sphere, consisting of a very thick, solid mantle and thin outer crust, surrounding an apparently molten core. The whole is charged with energy in the forms of gravity and heat. Gravity is a permanent, conservative force. Heat is a stimulant to action, but it is used up in doing work and it also escapes into space Since the earth is so very old and so much work has been done, all the heat energy from any original source such as a molten globe must long since have been exhausted Yet the earth is exceedingly active. How has the heat energy been kept up?

It may be recalled that astronomers and physicists at one time set a rather narrow limit on the possible life of the sun because it was radiating heat at a rate that could not be maintained for many million years, if it were due to the condensation of the sun's mass by its own gravitative attraction alone. Madame Curie solved the riddle when she discovered that an atom of uranium could and did change to lead and gave off heat in so doing. Atomic transformation is now recognized as the potent source of the heat of the sun and stars.[2] It also occurs in rocks of the crust of the earth in the so-called radioactive minerals. The thought lies at hand that similar reactions, occurring within the mantle, would generate heat and so keep the earth alive Investigations of this potent source have shown that it would long since have caused the melting of the earth if the proportion of radioactive minerals were the same throughout the mass of the globe as it is in rocks at the surface. Since the earth is not melted some limitation becomes necessary, and it has been attempted by several geologists by assuming that the active minerals may occur only in some thin shell of the supposedly stratified mantle. That is one idea. Another is that the active minerals may be irregularly distributed, as ores of gold are, for instance

Let us suppose that anywhere in the mantle there is a body of rock which contains more radioactive minerals than the adjacent masses and that there are also other bodies that contain little or none. The radioactive minerals slowly change and in changing give off heat, which being buried in the globe can not escape by radiation or conduction It must accumulate and melt the rock, the richer bodies melting first. Each one would then constitute a growing bubble of molten rock in the not yet melted surrounding rock. It is true of such a bubble, as it is of a bubble of gas in a liquid, that it must rise toward the surface whenever it gets big enough; and it is also true that it must spread out as it rises from depths where the pressure is greater into those where it is less.

[2] Russell, H. N., *Proc. Am. Phil. Soc.*, Vol. 81, 1939.

The general form of the bubble at higher levels will therefore be that of a flattened rounded disc. That is, so long as it is confined in the solid, but plastic mantle; when it reaches the rigid outer crust, it will tend to spread even more widely underneath it and also to penetrate any weaknesses, such as shearing planes, in its effort to rise still further. It then becomes an intrusive rock, forming narrow bodies, which may, however, be large enough to constitute such a mountain range as the Sierra Nevada in California.

Continuing this thought, we may suppose that such a body rose and having spread out cooled in the upper part of the mantle or lower part of the crust. It is then a compact, solid mass and as such offers more resistance to the rise of any later melt, which may come up from its heated roots, than that which is presented by the disturbed and altered rock around it. The later melt is therefore apt to appear as intrusive bodies or as volcanoes in the circumference of an older one. Such an arrangement is a common one, as we see in the arcs of volcanoes in the Pacific, for example, and also in the distribution of mineral deposits.

Have you clearly in mind the picture of the flattened bubble of molten rock or magma underneath the outer crust? The melt is surcharged with energy, it being hot and chemically active. The rock of the covering crust is crystalline, that is, it consists of crystalline minerals which are composed of molecules, in each of which the atomic forces are balanced. But they attained that balanced condition as the rock of the cover cooled from some previous heated state and now, being reheated, they will be disturbed. The crystals will reform in response to the chemical excitement and the external pressures around them, or, as the phrase goes, the rock will be metamorphosed. (Fig. 2.) In the process of change the molecular forces of the original crystals will become unbalanced and will enter forcibly into the reorganization of the minerals, but they will be influenced by any other stresses, such as surrounding pressures, because they must obey the law that requires the work shall be done with the least expenditure of energy, the law of least resistance. They will forcibly elongate in the direction toward the least opposing pressure, whatever that direction may be. What will it be under the conditions in the upper part of the mantle above the contact of the magma and its cover?

At the depths at which the recrystallization is supposed to occur the rock is under a weight greater than it can carry unless it be supported by adjacent masses. Equilibrium depends, therefore, upon the balance between the weight which is carried and the supporting resistances. The resistances are two, namely, the strength of the rock (whatever value it may have) and the horizontal pressures of adjoining masses. The latter will be less than the weight, for the strength is something. (Weight minus strength equals horizontal pressures, hence horizontal pressures less than weight.) If we now introduce the molecular forces of crystals in process of change we disturb the balance and the crystals in reforming must elongate in the direction of least resistance, that is, horizontally. This is the reasoning which it at the foundation of the hypothesis to be discussed, the hypothesis of *Metamorphic Orogeny*. Orogeny or mountain-genesis is by that hypothesis attributed to the force of growing crystals, which have elongated in the lower portion of the cover of a bubble of magma and have caused the cover to expand in such a manner and with such force that the margins are pushed up as mountain ranges: first the hot bubble, then the

gradual development of expansive force in the cover till the crust yields

That is a stupendous job! Is it possible that it can be done by hard, inert substances like crystals? That is just the point: they are hard and inert because they are so firmly held in balance by very great forces When those are released they reconstitute the crystal with proportionately intense action It has been determined by experiment that in crystal growth and change the *molecular forces come into play and cause the growing or recrystallizing structure to exert a force that is equal to the crushing strength of the crystal*

To illustrate crystalline change and the forces that may be exerted, even when the alteration occurs in cold rock, with no impulse except that of chemical attraction, attention may be directed to the example shown in Fig 3 The white layers in that rock are gypsum, the common rock of which plaster of Paris is made They were originally, when deposited under water, a slightly different mineral, called anhydrite, which consolidated to rock On being brought in contact with molecules of moisture each molecule of anhydrite took on one and thereby increased in volume, every 3 cubic inches became 4 cubic inches There had to be room and it was made by lifting the load, whatever it was But the lifting was accomplished by the layers, which were originally flat They elongated horizontally, exciting molecular force in so doing The individual crystals got behind each other and pushed the layer up into an arch, sliding it along on the interstratified layer of black clay beneath it As any one arch rose another began behind it and so a short section was folded up by the expansion of a very long stretch that remained flat The force that was exerted was equal to the shearing strength of the rock, as is shown by the fact that the layer which was too thick to fold was sheared along the dark, fracture lines.

The writer had a personal experience which is to the point It occurred when the Hetch Hetchy tunnel was being driven through the Coast Range near San Francisco, California Several miles of it penetrated a very unpleasant black schist, made up of very thinly laminated mica The mica-scales were not more than a few molecules, a few hundred thousandths of an inch thick, and between each pair of them were invisible cleavages into which molecules of water were drawn from the moisture of the air in the tunnel The molecular attraction was not very strong in any individual entry, but the combined effect of millions was irresistible It crushed the strongest timbers and squeezed out solid blocks of sandstone, where they were imbedded in the mica rock I saw it done Having climbed to a platform at the face of the tunnel and finding a projecting rock, I struck it with my hammer It responded at once, moving menacingly toward me, like the front of an automobile about to run over me That rock was alive and seemed possessed of a malicious spirit

These instances which have been cited to illustrate the force of crystals in growth or metamorphism present only minor effects, such as are produced without stimulation by heat The reactions are far more intense when the molecules are strongly agitated, as at high temperatures Very pronounced changes are seen in metamorphic rocks, where great alterations have been brought about at temperatures that approached the melting point High pressures also increase the action, and this is especially the case when there is sliding of one mineral over another and the mass is sheared into thin plates The molecular forces are then intensified by the shearing stress and the temperature is raised by the friction Extreme elongations amounting to sev-

eral times the original dimension in a given direction may result as the rock becomes fissile or even fibrous

Let us examine the process of change more closely Any response of the molecular forces to slowly rising temperature must itself be very gradual Any individual crystal should experience a slowly growing tendency to change its form When it eventually does so it obeys the law of its own being and adjusts any dimension according to the particular arrangement of atoms that best suits the environment along any given axis Any crystal changes without regard to its neighbors, in the beginning The effect within any area of a square foot or square mile is that of a mob But groups will by the law of chance develop mechanical resultants and so dominate contiguous individuals as to work them into the common trend In that trend the elongations of the individual crystals add up and the effect at the outer end of the line is a push with their combined forces and a displacement equal to the sum of their elongations

We may get some idea of the possible proportions of the change by considering the alteration of a granular igneous rock like granite or of a granular sedimentary rock like sandy mudstone to a laminated metamorphic rock with development of the common mineral, mica Measurements of mica crystals show that if the mineral substance originally had the form of a cube the length of the oblong, flattened mica crystal would be twice the side of the cube That is to say, the elongation in one direction would amount to 100 per cent, with corresponding thinning in other directions, provided there is no change of volume In those cases where the greenish, fibrous minerals grow the change of proportions is even more Indeed we might easily be misled into describing the elongations as amounting to exaggerated proportions if we did not distinguish between the effect of recrystallization, which exerts a molecular stress, and the effect of plastic flow, which is simply a squeezing out. But we do not need to assume extreme conditions. The horizontal dimensions of the larger molten bodies and the diameters of their covers are many miles in extent

Consider, for example, the plateaus of Asia, the nuclei of the continent. We have noted in a previous article[3] that they have repeatedly been intruded by molten granite, which has risen into and around the older eruptions in each successive activity The diameters of the areas thus intruded are many tens of miles, even two or three hundred. The proportionate expansion need not be great to produce an outward push and displacement amounting to miles in their margins

We may not let such an estimate pass, however, without recalling the dictum of Professor Andrew C Lawson, of the University of California, who has shown that in case of movement of one rockmass over another the dimensions of the moving mass are narrowly limited by the weakness of the rock[4] The friction sets a limit for the length of a slab which may be pushed over another without being sheared How can a layer tens of miles in radius be pushed away from a central area? Yet that seems to be the fact, since mountain zones are narrowed in that degree Could Professor Lawson be mistaken? In this case it would appear that he is not, for the conditions which he assumed would not exist At the contact of the cover with the underlying magma there is a transition layer in which plastic solids, molten liquids and hot gases are mingled and agitated by their mutual reactions Do you get the

[3] "The Growth of Asia," SCIENTIFIC MONTHLY, June, 1939

[4] "Isostatic Compensation Considered as a Cause of Thrusting," *Bull Geol Soc. Amer*, Vol 33, 1922.

picture? The slab or disc which constitutes the expanding cover rests upon this agitated fluid and gaseous contact zone. There is no friction, only a moderate resistance due to viscosity, and that is variable from place to place. Only when the margin of the magma is reached and the outward thrust begins to displace the solid framework would the friction of solid-on-solid come into play. Even then it would be lessened in any case where hot gases or melts followed intrusively along developing shears The outer slab that might be sheared off in this manner is such as we see as an overthrust sheet, and its dimensions are commonly of the same order of magnitude as those calculated by Professor Lawson, with lengths of fifteen to twenty miles

Reviewing the substance of the preceding pages, it appears that the hypothesis of Metamorphic Orogeny is equipped with power, may work with a terrestrial mechanism, and would by known processes of metamorphism achieve the upthrust of mountain arcs It may be explained that it is the survivor of a number of hypotheses to account for the folding of zones of the crust, which have been submitted to the tests of advancing knowledge, so far as the writer was able, during the past fifty odd years The list comprises all that have come in to his research net, including some that are still current with one school or another But all the others have failed, in his estimation, because they were either impotent or inadequate or mechanically defective or based upon assumptions that were in course of time disproved It does not follow, even in the writer's thought, that Metamorphic Orogeny is sound, but it is entitled to further consideration and may be tested against the facts presented by the development of various mountain chains, so far as they are known. It is my purpose to do that in a number of cases, but in order that the hypothesis may not lead me to believe that it is the ultimate answer (where we have so much to learn), I have laid down certain requirements which it or any competitor must satisfy to be admitted to examination. The habit of examining students for graduation leads one to regard any such hypothesis as a candidate for the degree of W. H, Working Hypothesis, and I would guard that degree as an honorable distinction.

Any hypothesis must be dynamically competent; that is, it must assume a source of energy, which will deliver power at the right time, in adequate amount, and in the right manner to do the work As a second requirement the hypothesis must operate according to mechanical principles, with rocks of the crust, on the scale of mountain building. Again, it must be capable of repeated action in the same region, after long intervals of inaction It must produce the peculiar pattern of curving mountain ranges, with abrupt terminations, and with nodes where two or more trends meet And the action must cooperate with or be related to other processes of terrestrial activity proceeding from a common cause in the same region, at the same time or in sequence

Most of these requirements seem sufficiently obvious, though often disregarded, but the concept of pattern may be more fully considered, because it is significant and the discussion may serve to point out certain misinterpretations.

Eduard Suess, the great Austrian geologist who compiled the monumental work, "The Face of the Globe," was the first to note and interpret the curved axes of mountain ranges His primary example was the Alps, which arch around the northern margin of the elongated basin of the Po. Suess took the arc to be an effect of bending and reasoned that the force which had caused it had acted to push the Alps northward. Generaliz-

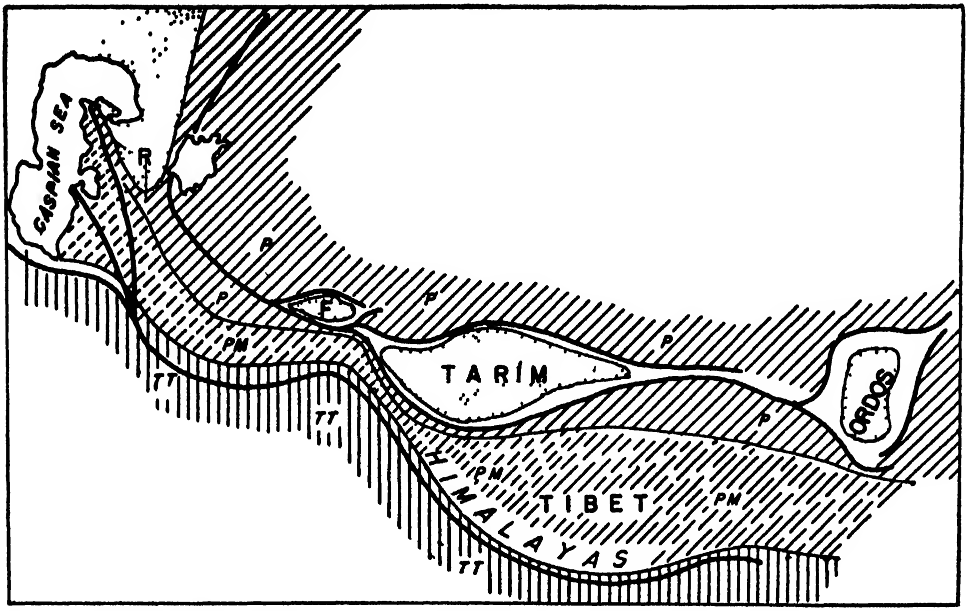


FIG. 4. STRUCTURE OF CENTRAL ASIA. DIAGRAMMATIC OUTLINE AFTER LEUCHS, GEOLOGIE VON ASIEN, 1937 OLD LANDS (PRE CAMBRIAN) INDICATED BY DOTS MOUNTAIN TRENDS SHOWN BY HEAVY LINES. AREA PPP IS THAT WHICH IS CHARACTERIZED BY LATE PALEOZOIC FOLDING. AREA PM IS THAT IN WHICH BOTH PALEOZOIC AND MESOZOIC FOLDINGS ARE RECOGNIZED AREA TT IS THE ZONE OF TERTIARY OVERTHRUSTS, PUSHING OUTWARDS OVER THE GANGES DEPRESSION THE ENTIRE REGION OF THE MAP IS DOMINATED BY THE YOUNG MOUNTAIN RANGES THAT HAVE BEEN PUSHED UP DURING PLIOCENE AND PLEISTOCENE TIMES AND HAVE ALSO BEEN LIFTED BODILY WITH THE PLATEAUS F—FERGHANA NUCLEUS, R—RUSSIAN NUCLEUS

ing on the concept, he applied it to all mountain chains and gave it definition by naming the front, the flanks, and rear, according to their relative positions, as of an advancing army

The generalization has been fully justified, and it may be amplified by pointing out that the arcs of mountain chains tend to occur as the raised margins of basins Look at the great plain of Hungary lying within the Carpathian curve and separated from the Adriatic depression by highlands of Bosnia and Dalmatia. Consider the Adriatic itself, bounded by the highlands on the northeast, the Alps on the north and the Apennines on the southwest With attention turned to the hollows or concavities of the earth's surface we may note the fact that Suess's interpretation means that the mountain-building force has raised the rims by pushing outward, away from the interior.

The ideal pattern would consist of round basins, but the effect is evidently not so regular Some depressions are oval, others are decidedly long. Where they are closely contiguous the common margin may run straight, as if mutual pressures had been opposed And where two or more meet at their ends there is a mountain knot

Suess applied the interpretation of mountain arcs, considered as evidences of an outward push, to Asia and logically reasoned that the great sweep of the Himalayas with its convexity toward the south implied a southward movement of the whole continent or of that broad mass of the continent north of the arc.

The idea suggested a drifting movement of the whole, to which it may be objected that there is no known force to cause such a displacement and there is behind the continent, north of it, no such hollow as its southward drift must have left The Siberian nucleus has not been disturbed during the several hundred million years which cover the time of the evident mountain-making episodes and seems to have been a fixed, possibly resistant mass. Reasoning thus, Willis in 1907[5] argued that the arcs might have been raised by a push from the oceanic regions toward Siberia. He thought the source of pressure should be sought in the Pacific and Indian oceans He was, I now think, influenced by his early observations in the Appalachians, where the push was from the direction of the Atlantic. He thought that ocean basins were the dynamic areas, that the continents were passive and that the latter had been squeezed, either by expansion of the former or by wedging It was not until many years later that he realized the incompetence of the crust to transmit mountain-building pressures to any considerable distance from their source and on that ground relegated the idea of *exclusively* oceanic expansion to the scrapheap The study of continental masses and their histories convinced him that they also had been areas of dynamic activity and that in that respect there is no characteristic distinction to be made between the crustal areas covered by the oceans and those which are lands He was thus led to consider the alternative hypothesis of expansion of smaller areas, which is the basis of the present discussion.

The wrinkles of Asia and the nuclei which they outline offer a number of opportunities for testing any hypothesis of local expansion, whatever be the supposed cause There are the ancient continental islands. the Angara nucleus, the Gobi desert area, Tibet, the Tarim plateau, the Peninsula of India and others which are less conspicuous Each of these nuclei had a long history of intrusion and mountain growth before the mountain trends we can now recognize were developed That ancient record has not been deciphered Among the more recent activities the periods of granitic intrusion and orogeny which occurred at the close of the Paleozoic era and again during the later Mesozoic and Tertiary, respectively some 200,000,000 and 60,000,000 years ago have left elements of the pattern which invite consideration. The earlier of these two may presumably be studied in the Gobi region and the mountain arcs which surround it on the south and southeast, the enormous mass of the Great Mongolian granite, which rose toward the surface in that area during some period of the Paleozoic being the exciting fact, but the case lacks definition because the date of the intrusion is not yet well established and its relation to any epoch of folding can not be determined The Mesozoic record is more evidently related to the outstanding mountain ranges Even there, however, where we see the youngest visible granites at the surface, we have to remember that they are older than the youthful mountains and that any magma to which we may attribute metamorphism or other effect must be hidden beneath the crust, under the plateaus

It happens that the most conspicuous of all mountain chains, the Himalayas, is that of which we have more precise knowledge and which best lends itself to our purpose of testing Metamorphic Orogeny The arc sweeps majestically around the southern margin of the Tibetan nucleus It is marked by a central zone of granite of late Mesozoic and Tertiary age, part of the widely distrib-

[5] "Research in China," Vol. II, pages 118–126.

uted intrusions of that time, which built up southeastern Asia as we now know it The mountain mass is intensely sheared and folded, squeezed into a relatively narrow belt The apparent movement has been away from Tibet and toward the Ganges depression, as is seen at the southern base of the range, where the foothills are thrust out upon the valley plain. But we will do well to pause and consider our postulates, before we are carried too far by favorable appearances

Our basic assumption is that there is a molten body beneath the plateau of Tibet What evidence is there to justify that? There is no conclusive evidence In the absence of volcanoes or other surface indications of subterranean heat the assumption is an inference, which, however, may put in claim for acceptance as such on the following grounds It is established by the occurrence of the Tertiary granite that there was during a geologically recent time a highly heated condition in the marginal zone of Tibet, at a depth from which that body was extruded It is improbable that the crucible could have cooled to solidification, if situated at even a moderate depth below the crust, and even though it lost a large amount of energy in consequence of the extrusions, it remained liable to reheating by any remainder of radioactive minerals, *i e*, heat generators

A second reason for thinking that there may be a molten body beneath the Tibetan plateau springs from the elevated position of its eroded surface The type of flat plain, dotted with residual hills, to which it belongs, can be sculptured only near sea level It has been raised some 15,000 feet There are three ways in which such an uplift may be produced; a section of the crust may be squeezed up, as mountain ranges are; or it may be arched up by the intrusion of lava between two layers, as in the classic instance of the Henry Mountains in Utah; or it may be lifted in consequence of and by an increase in *volume* of underlying rock. An example of the first kind, a mountain range, is long and narrow and presents a characteristically crushed and folded structure Belts of that nature occur in the Tibetan plateau, but they represent older mountains and can not be the cause of the younger uplift The possibility that a layer of rock, 15,000 feet thick, may have been inserted beneath the plateau is ruled out because any such mass would have increased the attraction of gravity over the average normal value and observations fail to indicate that excess There remains the inference that the volume of an underlying mass has been increased, as by a swelling action The alteration of anhydrite to gypsum, which we have noted, suggests one process, but it is not probable that any transformation of minerals could occur throughout a layer of sufficient thickness and extent to produce the elevation Another process, and the only one possible so far as we know, is melting. It is an appropriate action, since it would affect every square mile similarly and would produce a more or less uniform uplift The increase in volume, concentrated in vertical displacement, would be about 5 per cent of thickness of the solid rock before melting; that is to say, a layer 60 miles thick should have melted to produce an uplift amounting to 3 miles. Given a highly heated body, containing sparsely disseminated heaters and situated in the mantle, below the crust, melting appears to be reasonably probable

A sidelight may be thrown upon this inference by reference to the fact that the Himalaya mountains are lighter, considered as a weight on or in the earth's crust, than they would be expected to be. This fact was discovered by the surveyors of India as far back as 1855, and it led to the suggestion that the mountains had

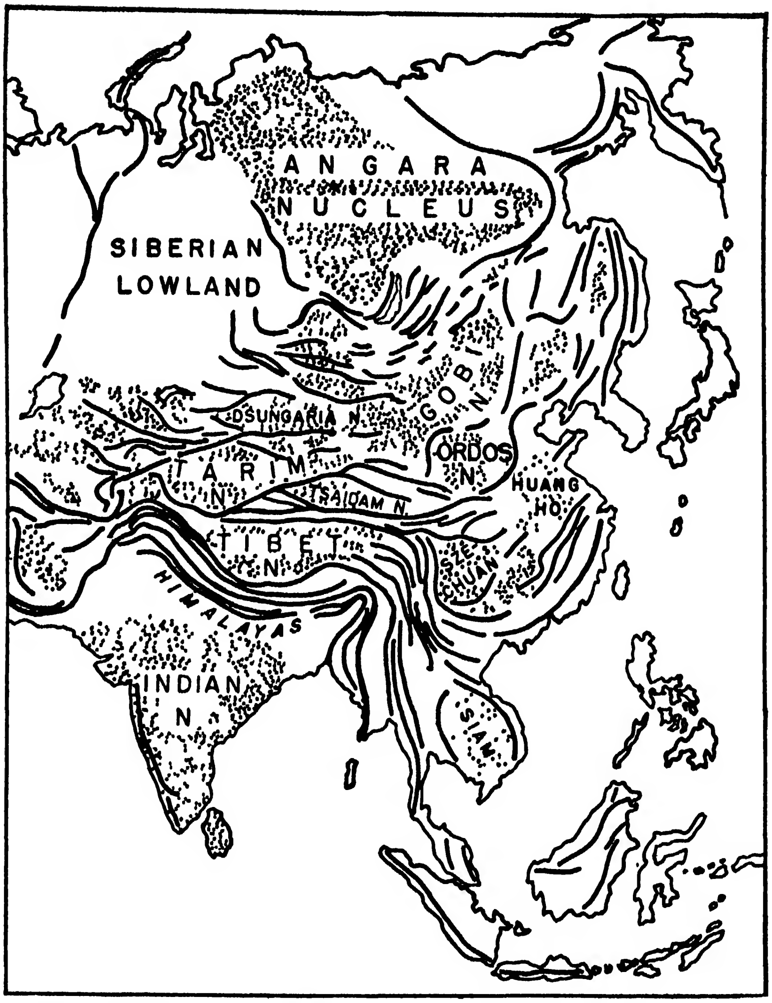


FIG 5 MOUNTAIN RANGES OF ASIA THE HEAVY BLACK LINES REPRESENT THE AXES OF MOUNTAIN CHAINS, WHICH SURROUND OR SEPARATE NUCLEI OF THE CONTINENT THE MOUNTAINS ARE MADE UP LARGELY OF SEDIMENTARY ROCKS, THAT WERE DEPOSITED BENEATH MARINE WATERS THE NUCLEI CONSIST CHIEFLY OF GRANITE INTRUSIONS AND METAMORPHOSED ROCKS, THEY HAVE BEEN DEEPLY ERODED AND WERE THEREFORE LAND AREAS. THUS THE MOUNTAIN RANGES AND NUCLEI PRESENT A PICTURE OF AN ARCHIPELAGO COMPOSED OF CONTINENTAL ISLANDS AND OCEANIC STRAITS THERE ARE GREAT DIFFERENCES OF AGE AMONG THE ROCKS YOUNGER SEDIMENTS AND MORE RECENT INTRUSIONS OF GRANITE ARE FOUND IN THE HIMALAYAS, THE MALAY PENINSULA AND SOUTHEASTERN AND EASTERN CHINA OLDER SEDIMENTS CONSTITUTE THE CENTRAL AND NORTHERN MOUNTAIN RANGES EACH OF THE MARINE STRAITS WAS CLOSED IN TURN WHEN THE SEDIMENTS DEPOSITED IN IT WERE FOLDED UP AND RAISED AS PART OF THE CONTINENT THUS ASIA HAS GROWN FROM NORTH TO SOUTH AND SOUTHEAST BY THE WELDING TOGETHER OF THE NUCLEI. THE PENINSULA OF INDIA IS A VERY ANCIENT NUCLEUS, WHICH HAS ONLY RECENTLY BEEN CONNECTED WITH THE CONTINENT BY THE FILLING OF THE GANGES TROUGH.

deep roots of the relatively light rock, granite, sunk in heavier basalt, so that the mountains might be thought to be floating, like icebergs Definite proof of the explanation is difficult and there has been much controversial discussion of the "roots of mountains" or Airy theory and the alternative suggestion, the Pratt theory of balanced masses. Airy's view has for several decades met with little favor among geodesists, but it has of late gained more credence among geologists, and quite recently it has been demonstrated by earthquake waves that the Sierra Nevada of California has a granite roof, at least 20 miles deep In connection with the uplift of Tibet we may only say that a melted root would be lighter than a solid one, and the effect would be to float the plateau.

Proceeding from this inference, from which we deduce the effect of metamorphism of the under side of the crust or of some deeper layer forming the cover of the molten body, we may next inquire whether the movement of the mountains has been in the direction in which metamorphism should push.

According to the general inference formulated by Suess the arching progresses outward on the convex side of the mountain arc, southward in the case of the Himalayas. There in the foothills of the mighty range geologists have long recognized the fact that the heights are moving forward over the lowlands It may be that the lowlands are being pushed northward under the heights and that the zone of extraordinary thrusting of sheet upon sheet of rock is being actively squeezed from both sides, but that possibility does not invalidate the evidence of southward movement of the Himalaya mountains, outward from Tibet

Turning our attention to Turkestan and the Tarim Plateau we there see the arc of the Tianshan presenting its convexity toward the north, as if pushed out from the Tarim basin; and grasping the whole setting of Tibet and Turkestan in our view, we see that between the two apparent centers of expansion, Tibet and Tarim, stretches the nearly straight range of the Altin Tag, which thus lies in the zone of pressure from both sides.

The interpretation of these facts, according to the hypothesis of Metamorphic Orogeny, is that there is a hot spot under each of the wide plateaus and that the disc above the heated layer is expanding in consequence of the elongation of crystals in the process of metamorphism. The width of the Tarim basin is about 350 miles and that of Tibet exceeds 500 miles Very moderate changes of crystalline proportion would satisfy the requirements of the displacement of the mountain zones, including both the take-up in folding and the over-thrusting of the folded masses, provided that each of the discs had expanded all over and had pushed away from their common boundary in the Altin Tag, but uniform action is very improbable. We shall come nearer to the facts if we assume that the hot spot comprises a variety of conditions, ranging irregularly from molten to pasty solid, and that the effects of recrystallization have been correspondingly unequal in different areas

A zone of very intense action is found southwest of the Tarim basin in the northwestern Himalayas, where the peaks of the Karakoram range stand as the highest in the world, exceeded only by Mt Everest, at altitudes of 27,000 to 28,000 feet Their sculptured pyramids are residual heights, whose pedestal is the plateau that extends from their feet at about 15,000 feet Their alignment in a northwest-southeast direction in a nearly straight line is that which a mountain trend should have if it were raised by pressure from the Tarim side, and the intensity of compression would result

from expansion of that oval disc in the direction of its major axis.

Thus it seems as though Metamorphic Orogeny might work to produce the pattern of the mountain ranges of the part of central Asia that includes the highest and most extensive plateaus and mountains of the world, and that it offers a force adequate to the task of lifting the vast region to its actual altitude and of compressing the mountain zones It suggests that the present repeats the past in so far as the uplift of continental plateaus, the upthrusting of mountain ranges and the subsequent erosion of highlands to graded plains have again and again followed the development of molten bodies beneath the outer crust of the earth, in consequence presumably of local, radioactive heating It answers the three questions What is the force that is stronger than gravity? What is the horizontal force that wrinkles the face of Mother Earth? And what is the relation between the two?

The claim of the theoretical process to the degree of *Working Hypothesis* seems strengthened Yet so long as it rests upon the inference of subterranean melting, without more adequate demonstration of that basic condition, it must remain on trial The Japanese Archipelago seems to be a hot spot Perhaps a study of the dynamics of that region might lead further

However, before we go to Japan, where we meet not only the problems of Asia but also those of the Pacific, it may be well to try to decipher the history of the continent according to the hypothesis which we entertain as an explanation of its nuclei and mountain arcs Our major postulate is that the granitic layer of the earth's crust which we call Asia has been built up by numerous eruptive bodies, that have risen here and there from within the globe, at intervals of a hundred million years or so during the last two billion years Any eruption may have produced a notable granitic nucleus. Any nucleus may have been the seat of repeated intrusions. The margins of any nucleus may have been the preferred path of ascent of later intrusions from the same source as that which yielded the earlier one A small nucleus may have been like Ceylon, larger and presumably complex ones are now represented by Angara, Gobi, India, etc At any given time during the growth of the archipelago the spaces between the nuclei were troughs, through which sea waters flowed and in which sediments were deposited.

This major postulate is supplemented by that of metamorphic orogeny, which we have applied to the development of the mountain arcs How does that hypothetical explanation work when tested against the arrangement of the nuclei and their sequence, so far as we know the facts? Can the processes have produced the pattern of the wrinkles of continental Asia?

Angara and Gobi are among the oldest of the nuclei Each of them had a long, early history, which we can not yet read in the confused and distorted masses of ancient, metamorphosed rocks Whatever the mountain ranges of those remote ages may have been they are now ghostly visions of the imagination But around the nuclei there remain distinct traces of younger mountain trends, which envelop Angara on the east, south and southwest and border Gobi on the east and southeast Between the two stretch several ranges, whose alignment is attributable, it would seem, to the expansion of either one against the resistance of the other Granite intrusions of as late a date as the Paleozoic era and mountain folds apparently related to them occur in the Gobi region and around its margins These curves are predominantly convex toward southeast and south, but the little Ordos nucleus exhibits evidence of a push to-

ward the northwest as well. In central Asia the general east-west trends are seen to be composed of arcs which frame the nuclei of ancient rocks, but which by their height and youthful sculpture show that there has been mountain-making action during comparatively recent geologic periods The effect, when interpreted according to Suess's concept of an advancing curve, indicates that each nucleus has been a dynamic body, pressing against adjacent masses, while the general resultant was an outward thrust, southward and southeastward

Marine strata of Paleozoic ages which are folded up in the bordering ranges around the nuclei of central Asia indicate the former existence of deep and more or less connected or interrupted straits between the islands During the ages of the succeeding Mesozoic era, for more than a hundred million years, there stretched across Asia and Europe a long narrow sea, called the Tethys, a sort of long Mediterranean In Asia it occupied the region which is now Tibet and extended to the east and west Sediments accumulated in its waters to the depth of many thousand feet, and it is obvious that the crust of the earth was depressed or sank below some previous level to great depths and also that it has been raised during later times to its present height According to the hypothesis which we are considering the subsidence may be attributed to slow cooling, solidification, and shrinkage of volume of the sub-terrane beneath the Tethys, while the uplift during later periods follows from subsequent meltings and consequent increase of volume, as we have suggested in the earlier pages Interacting with two or three epochs of melting and uplift or occurring in sequence between them (the details of dynamic relations are not yet clearly read) there occurred activities of folding Strata of Jurassic and Cretaceous ages of the Mesozoic era are intensely folded in mountain ridges that traverse the plateau of Tibet They once formed ranges of greater relative height above the plateau than they now exhibit, but they were eroded and the plateau surface was planed by erosion to a graded landscape of broad valleys before the whole mass was raised to its present altitude In the meantime the basin of Szechuan, which also was part of the Tethys trough and was filled with sediment, has remained depressed or has subsided in recent times, while Tibet has been pushed up These various and diverse movements can not be explained by any simple mechanical action of pressure from an extraneous source They seem to demand internal activities, originating within each nucleus in the lower part of the rigid crust and operating to expand the area in such manner as to cause the margins to be thrust outward The hypothesis of repeated melting and metamorphism is framed to meet these requirements

TO WHAT EXTENT IS A SCIENCE OF MAN POSSIBLE?

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I

KNOWLEDGE of man has been growing slowly over thousands of years. But a science of man is something new under the sun. For though science is knowledge, it is a special kind of knowledge It is obtained by scientific methods, usually involving a collaboration between theory and experiment Most science is based on the quantitative analysis of measured phenomena It differs from other knowledge chiefly in its quality of being demonstrable An experiment to have scientific value must be one that can be repeated. Scientific phenomena can be measured and recorded over and over again or related by theory to other phenomena that can be repeated. New knowledge of this sort becomes generally accepted when it has been checked over by a sufficient number of people. The older type of knowledge which is derived from personal observations and the conclusions of authorities is harder to check up on, is more subject to personal bias and the mental fashions prevailing at any given time. Scientific knowledge, on the other hand, is cumulative in its effect and has a known predictive value.

In a hundred thousand years, by his use of the old forms of knowledge, man developed an environment suitable for a civilized life He domesticated animals, produced cereal crops, and through the great religions aspired at least to a noble concept of the dignity and character of life

Then, in a few brief generations, the new forms of knowledge which we call science brought to men a marvelous control of their environment—railroad, telegraph, telephone, electric light, motor car, submarine, aeroplane, radio, television, reduction of labor needed on the farm, canned and frozen foods, cheap goods by mass production, sanitation, medicine and public health. Almost over night the natural and physical sciences have brought these changes

The biological quality and the training of man has not undergone comparable changes. Except for medicine, we know so little about man that it is still fair to ask, "Can we have a science of man?" And the question is, somehow, troubling. Man's new power to control the environment has not made him humble He seeks new short cuts to happiness The older knowledge of man, heritage of ages of experience and suffering, he tends to discount, because it is not based on the new scientific method, not capable of scientific proof He is not likely to go back permanently to the old knowledge. He is too impatient of its restraints, too admiring of the success of the new type of thinking based on the scientific method. Yet without more knowledge of himself, of his needs, his weaknesses and his possibilities, we may wonder whether man can safely handle the extraordinary tools he has recently created. They may inflict irreparable injuries. If we ask, "To what extent is a science of man possible?" perhaps we are really asking to what extent can we achieve a secure and permanent civilization?

It is hardly encouraging to compare the present state of the science of man with the marvelous development of the natural

sciences. But the picture is a more hopeful one if we make allowance for the respective ages of these two fields of science. Several generations of men have been trained and taught in the physical sciences But no one of the age of forty-five or more to-day could have had any serious training at college in the sciences that have to do with man They were not available for teaching twenty-five years ago, which is a pretty brief span of time, even in this hurried age.

Scientific work in psychology was in its infancy at the turn of the century Mendelian genetics were rediscovered in 1901 At about the same time anthropologists got out of their armchairs and began collecting ordered data in the field By 1910, text-books were beginning to make significant use of new scientific materials in these fields By 1920, courses in scientific psychology, genetics, human biology and anthropology were available in most of our universities. To-day these subjects are among the most popular of any that are offered But much that is taught about man and society is not science Not enough research has been done to supply the basic material needed; and, still more important, there has been too little time for critical analysis, interpretation and organization of the research that has been already carried out Notwithstanding this present handicap, the sciences of man have already begun to influence our thinking in a way which suggests the effect that they may have in the future when they are more fully developed A few examples will make this clear

II

Psychology has made important contributions to present-day points of view There are some two thousand registered psychologists in the United States to-day, where there were only a few scattered individuals in 1900. The sum total of their research fills innumerable volumes. But much of this research has been badly done, as would be expected in so new and difficult a field.

Some of the most important work in psychology has been that on the development and experimental application of psychological measures, which are the necessary tools of acceptable research. Methods of measuring intelligence have been used extensively and criticized and refined during the last twenty-five years. Their weaknesses and limitations are now fairly well recognized and understood. In the hands of competent psychologists they have given us what little scientific knowledge we have concerning the origin and development of the faculty of intelligence which most distinguishes men from other forms of life

There is still controversy among psychologists, part of this may be described as a controversy between older schools of psychologists and those trained during the last decade Laymen who engage in controversy are often found to be leveling their lances against concepts and methods that have been completely discarded by critical contemporary psychologists. Much of this controversy relates to the roles of heredity and environment in the development of intelligence Recent work goes far to clarify this difficult field. In the past few years, the so-called fixity of the I Q has been disproved We know now that a stimulating environment in the home, in pre-school, in elementary school, in high school, in college and in later life tend to raise the I Q of an individual, and to maintain it at a higher level We know that in a depressed environment intelligence fails of a normal growth A child of two with apparently normal intelligence may in the unstimulating surroundings of a badly run orphanage revert to feeble-mindedness On the other hand, there are important differences between individuals

in the extent to which they respond to the stimulus of the same environment. Individual differences do not disappear when the environment is equalized at a high level In a stimulating environment, able individuals show a capacity for response which takes them further than ever out of the class of those of average ability. Among Newman's 19 pairs of identical twins reared apart, there were 11 pairs in which the two members of each pair had had similar amounts of education In each such case the twins differed in I Q only about as much as the same individual would vary when tested at different times, the average of differences being 4 4 points Among four of the pairs there was considerable difference in schooling between the members of each pair, their I Q 's differed on the average by 10 points Among the four remaining pairs, educational differences between the members of each pair were large, and in these four cases the twins differed by 19 points, on the average In every case the twin with the more education had the higher I Q But at the same time where one twin was dull for his poor environment, the other was dull for his good environment, and where one twin responded well to his poor environment, his mate responded well to his good environment

Twin Eleanore only got as far as the fifth grade, and attained an I Q of only 66 Her sister Georgiana went through grade school, high school, four years of music and three years of normal school After all that education, her I Q was only 78 It is hard to escape the conclusion that this pair of identical twins were not endowed with the genetic factors necessary to ordinary intelligence

Twin Gladys, with only three years' elementary schooling as the total of her education, had the creditable I Q of 92 Her sister Helen, with a college degree, had an I Q. of 116. Evidently the genetic endowment of these girls was sufficient for the development of average intelligence

The findings on identical twins reared apart check pretty well with other studies on the relative contributions of heredity and environment to individual differences in intelligence in the general run of our population. Of course, nineteen pairs collected by Newman and one by Muller is a number woefully inadequate for statistical validity, but this inadequacy is typical of the present state of the science of man.

If heredity is indicated as an important factor in differences in the intelligence of individuals, this is far from being the case with respect to differences in average intelligence which are found between socio-economic or occupational groups There have been five studies of foster children in which it was possible to distinguish the occupational or socio-economic grouping of their true parents. These are the studies by Burks of California, by Freeman of Chicago, by Leahy in Minnesota, by Skeels in Iowa and by Lawrence in England In the Freeman and Skeels studies there is evidence of selective placement That is, the brighter children were more often than not placed in the superior homes In the other studies this was apparently not the case The findings from all five studies were similar The children whose true parents were in the lowest occupational or socio-economic groups had an average I Q about 6 points lower than that of the children whose true parents were in the upper occupational or socio-economic groups, the foster homes being in all cases carefully matched for educational stimulus This difference of about 6 points indicated as the contribution of heredity is small, and becomes even less significant on further analysis of the methods necessarily employed in these studies If it had been possible to set

these studies on a better basis, it is likely that an even smaller difference would have been shown. If these are the indicated differences between the relatively small group at the bottom and top levels respectively, then the differences in hereditary capacity between any of the larger groups are of little importance As in the case of identical twins, the number of studies is quite inadequate for final conclusions But even these tentative findings point to some interesting inferences

If innate differences in intellectual capacity are on the average so small between different occupational classes, then our educational system should not be permitted to become a class affair The American ideal that would open the highest educational opportunities to young people from every rank of society would seem fully justified. On the other hand, if hereditary factors are of major importance in determining differences in intelligence between individuals in a similar environment, then our educational system should be pointed up to meet the needs of individuals at different levels of genetic capacity

Thus, the recognition of individual differences shows the need for the separation of the sub-normal from the intellectually superior in their class of work if either group is going to benefit fully from its education The beginning of such a separation is being made in some schools to-day It is one of the important contributions made so far by the budding science of man This process of fitting the education to the capacities of the individual will undoubtedly continue as our educational system becomes increasingly affected by our growing knowledge of individual differences in capacity

III

In the field of genetics, the marvelous advances of the past forty years have been largely limited to the genetics of plants, insects and animals For some reason, human genetics has been largely neglected in this country compared to what has been done by Fisher, Haldane and Hogben, in England, and by Verschuer and others in Germany There is almost no knowledge of genetic factors in normal variations in general qualities, such as intelligence, character or susceptibility to disease Important work has been done on blood groups A considerable number of infrequent abnormalities are known to be due to genetic factors, and in some cases the mode of inheritance is known Research work on genetic factors in feeble-mindedness and in mental disease is almost all in the future. Nevertheless, there are many signs of an aroused interest in the medical profession and a new recognition of their responsibility for preventing the spread of serious hereditary defects

Ultimately, scientific knowledge in regard to the part played by genetic factors in causing individual differences, and further research on the inheritance of different genetic factors, may make possible measures that would tend to discourage the reproduction of inferior genetic strains and encourage the reproduction of those above the average

Thus, scientific knowledge of the relative parts played by heredity and by environment in developing individual differences may become a valuable tool for improving human qualities, first on the environmental side through changes in education and ultimately through raising the average hereditary level

IV

Anthropology has made at least one important contribution to the American point of view by showing the extent to which culture patterns are fixed by the social environment with little regard to the type of people involved Many of the

qualities commonly spoken of as "racial characteristics" are now known to be matters of social rather than genetic inheritance. The whole concept of race has undergone a violent transformation in the past fifteen years. It is said that Hitler during the two years he spent in jail before coming to power read widely in what were then supposed to be scientific books dealing with race They were not scientific in our present definition of the term. they were the German analogies of Madison Grant's "Decline of the Great Race," which was having a vogue in this country at that time. Modern research of a more scientific sort denies most of their conclusions. It is interesting to speculate on what would have been Hitler's attitude towards race if he had had access to present scientific knowledge

These few and tentative conclusions are suggestive for the future, but they do not indicate to what extent the science of man may be possible. It is only very recently that we have really lifted age-long taboos against an honest examination of ourselves. In the past twenty years more of a start has been made than might reasonably have been expected under the circumstances The prospect for the future seems hopeful The extent to which we can have a science of man would seem almost unlimited provided three major conditions are met.

The first is plenty of time

The second is the enrolment in this work of men of high abilities, with adequate support

The third is freedom of thought, freedom of inquiry and freedom of criticism

V

Research problems concerning man are, in many cases, no different in kind from research problems concerning other forms of mammals on which effective work has been done. But the problems of man are infinitely greater in complexity and require more time in proportion as the space between human generations is longer than the space between the generations of the smaller mammals. What Tryon learned about the genetics of maze-running ability in rats might be duplicated in human beings with regard to genetic factors in differences in general intelligence, but it would take 200 years and a quite inconceivable control of human breeding to carry out such an experiment The difficulties of studying environmental influences are almost as great, but there is no reason to believe they can not be solved by sufficiently persistent effort and by the development and application of new methods.

There remains one important difference between the study of animals and the study of man, namely, that in the latter case man is studying himself and thus finds it more difficult to exclude his personal and emotional biases and reactions. It is for this reason, among others, that freedom of criticism is as important as freedom of thought in the development of the science of man. With all these difficulties taken into account, there is still every reason to believe that the development of the science of man will go forward rapidly from its present modest beginning

VI

It is worth while to consider the different practical applications that may result from the sciences of man The first has to do with education. Present methods of education are the product of a long evolution under the guidance of the old type of knowledge. On the whole, education to-day is undoubtedly better then the education available in the past. But we do not know in any precise way what a modern education really does or the different effect it has on different types of people. Psychologists in great number are working on new measures for deter-

mining individual capacities along different lines. Other psychologists are trying to determine the effect of different educational environments on people of different capacities. We may be sure that there is no single environment that would be the optimum environment for every one. Each individual will make his maximum development in the environment that will most stimulate the particular responses of which he is capable The environment that would be optimum for a dull person would be insufficient for the full development of a superior person. In the studies on orphanage and preschool children being made by Stoddard at the University of Iowa, the brightest children showed the least growth in the deprived environment of the orphanage The Pennsylvania Inquiry on school and college education by the Carnegie Foundation indicates wide individual differences in ability to respond to a college education A considerable proportion of those going to college go backwards rather than forward intellectually during their last four years of schooling It is not too much to hope that work of this sort will develop a science of education such that ultimately we shall be able to measure the specific potentialities of each individual and provide an educational environment which would be the optimum for each of his particular abilities. Such a change in our educational system if universally applied would probably raise the average I Q almost 20 points. Few people would remain without some specific capacity which, properly developed, would make them more valuable members of society in their own recognized specialty

With respect to the development of character and a balanced personality, scientific advance is more difficult than in the field of intelligence, but work is now going forward which will hasten the revolution in our treatment of criminals, and which will ultimately greatly reduce the number of anti-social, distorted and unhappy personalities; and even for the normal child will make possible a more socially adapted and happier personality

VII

To date, the most effective applications of a science of man have been in medicine, nutrition and public health The expectation of life at birth is now double that prevailing a century and a half ago, and has been increased from 49 2 years in 1900–1902 to 60 3 in 1929–1931 Medicine had a long start on psychology It is not unreasonable to suppose that in another fifty years we may have a science of man which can prescribe the optimum environment not only for the maximum physical but also for the maximum intellectual and personality development of each different individual The application will not be easy But when the knowledge is available, some way will be found to apply it.

The science of human genetics will ultimately supply psychologists with additional knowledge necessary for an understanding of different human types But the major applications of the science of human genetics will be in the field of direct improvement of the genetic qualities of human stocks. That is far in the future What a few men did in twenty years, working in *Drosophila*, it may take several hundred men a hundred years or more to do working on man. Given sufficient time, and the development of new tools of research which will surely take place, a fairly complete genetics of man is possible Whether its practical applications will be important, I leave to you to decide Does your experience in plant and animal genetics lead you to think that the average man's socially valuable qualities in our changing environment could be improved by creating conditions in which superior strains

have the larger families and in which the breeding of inferior strains is effectively discouraged?

VIII

We have been considering only the sciences relating to individual differences and individual development, and the contributions which these sciences may make to the improvement of human beings But the study of man can not proceed independently of his environment and his activities, which are the field of the so-called social sciences Nor can the social sciences proceed successfully without more knowledge of this strange and complicated creature, man The development of the science of man should therefore have another important effect in the contribution it will make to the sciences which deal with the behavior of men in the mass and their relations to each other

All branches of sociology are at present handicapped by lack of knowledge of the human material whose activities they are studying The postulate of the economic man, impervious to all other emotions, does not add to the reality of economics Perhaps the new field of population study provides the best example of the interdependence of studies of man and studies of man's activities Here the analysis and forecasting of total population trends has been revolutionized since 1925 by the introduction of procedures for taking changes in age and sex composition accurately into account. It is safe to say that the error in population forecasts for the United States for the next thirty years has been cut in half by the application of these techniques, and equally important information about future age distribution has been added, which was wholly lacking before

The study of the adjustment of the population to resources in different parts of the nation, which had never been given serious attention before 1930, has been developed to the point where its results already have very practical and far-reaching significance The study of differential reproduction rates, which prior to 1930 had been based chiefly on such fragmentary and inaccurate data as reports by college students about the numbers of children in their fathers' families, has been extended and refined until it is possible to describe the reproductive tendencies of most population groups in the United States with considerable accuracy, and we are now beginning to get accurate information on how these rates are changing in different groups under different conditions. It may be hoped that the 1940 census will supply the necessary materials for far more accurate and extensive studies along this line.

But these so-called group differentials in fertility relate only to occupational groups or to regional groups We know that farmers have more children than city people, but we do not know what genetic types are surviving in the greatest numbers It is impossible to say at present on the basis of any scientific evidence whether the human race is improving or whether it is deteriorating This important question, with all its practical implications, can be answered only when population study can employ measures of innate human qualities, and for these it must wait on the development of the sciences of man

Thus, the science of man may not only make it possible to improve man himself by supplying the proper environment for his development and, ultimately, even by an improvement in his genetic potentialities, but may give the social sciences sufficient precision to make them truly sciences capable of predicting the end results of current political, social and economic trends

The sciences of man may in these ways make an invaluable contribution to human welfare. They may also make

an even greater contribution in setting up new concepts of human possibilities, new ideals as to the purpose of life.

IX

In the long period of comparative world peace which lasted 100 years from the Battle of Waterloo to the outbreak of the World War, there seemed to be a growing recognition that the physical well-being and the fullest intellectual and moral development of individuals was the highest goal of society This ideal of individual improvement was eclipsed by the old barbarism which emerged in the war and by the desperate struggle for power that has followed We seem to be going back to primitive aspirations in which the improvement and happiness of the individual are subordinated to the power of the state A return to religion would prevent this trend going further, but a new stimulus is needed That stimulus may lie in the science of man When we have a clear picture of what an optimum environment can do for the development of the individual, when we understand better the extent to which inferior genetic qualities may limit human development compared to the full flowering of those with a superior inheritance, when we realize that for each region of the earth and for each stage of its civilization there must be an optimum population at which its people are best supported, when economics and sociology understand the human material with which they are dealing and become in their turn sciences of human relations, when we have in our hands demonstrated scientific tools capable of vastly raising the level of human relationships and of the developed qualities of man, may we then not hope that men will be moved to new aspirations commensurate to their new possibilities? Science will never take the place of religion in revealing the ultimate mysteries and purposes of life—whence we came, our purpose here on earth or what lies beyond But religion is also concerned with improving the lives of human beings, and hence religion will be strengthened by the sciences of man as they demonstrate methods for attaining a new and higher ideal of man's life on earth And the demonstration that such an ideal is possible is the first step towards attaining it

ENGINEERING—ANCIENT AND MODERN[1]

By E. H HULL

GENERAL ELECTRIC RESEARCH LABORATORY

RECENTLY we have indulged in much back-patting and self-congratulation on our modern engineering progress. Let us go back a few thousand years to see what we have which the ancient peoples lacked. In general we will find that most ancients had a large number of products and devices which we think of as modern. For example, there are now large industries making boards from cornstalks, artificial silk from wood, automobile steering wheels from soya beans, and so on. In the pre-Christian era there existed industries which supplied imitations of things too expensive for the common people, such as metallic alloys resembling silver and gold, artificial pearls, a cheap dye matching the costly Tyrian purple, artificial amethysts and other jewels from glass.

Suppose we hastily review the knowledge of ancient peoples to evaluate their possibilities in engineering achievements The more advanced races had developed out of the stone age in prehistoric times They used copper and bronze implements before written history, hardening these soft metals by hammering By about 1000 B C iron was replacing bronze for many uses Smelting of metals was successfully practiced as well as the metal-forming processes of forging and casting

Somewhat later steel was made from iron and hardened by quenching in water or case-hardened by baking in charcoal and then quenching Homer in the "Odyssey" mentions hardening iron by quenching, and in the Iliad he gives a vivid picture of armor-making, using fires, bellows, tongs, hammers and anvil to form gold, silver and bronze into elaborate designs Some idea of the prevalence of iron in 700 B C is indicated by the discovery of 176 tons of rectangular iron billets in the storehouses of the Assyrian king Sargon II

With these materials, hand tools for all trades were made in numbers and variations nearly equivalent to the present-day list In certain instances the ancient tools show a more refined design than our modern examples

For rock-cutting the Egyptians employed copper saws set with corundum teeth capable of working in slabs of rock 7½ feet thick Core drills set with jewel stones for drilling rock could turn out work which has been judged the quality equivalent of our modern reinvention, the diamond core drill

The theoretical equipment of the ancients was not great until developed in Greece during the last few centuries B.C. Previously all designs were based on experience and rule of thumb This is true to a large extent in some branches of modern engineering It is also true of the Roman engineers after the decline of learning in Greece

The early Egyptians could do simple arithmetic, and were expert at measuring because of the yearly necessity of resurveying the flooded Nile valley. Despite their lack of theory the Egyptians made some remarkable structures We have all been awed by the size of the Great Pyramid, but actually size in a structure of that type is just a matter of time, money and tremendous quantities of slave labor In my opinion the astonishing thing about the Great Pyramid, built in 4700 B C, is not its magnitude but the accuracy with which it was laid out and built and which it has maintained. One investigator, after careful measurement, has shown the sides to have a mean error

[1] Presented on the W G Y Science Forum

of only six tenths of an inch in 756 feet. For comparison, a carefully machined part of a modern automobile might be held to within plus or minus one ten thousandths of an inch in a one-inch diameter This allows an error of 2 parts in 10,000, whereas the pyramid error is only 7 parts in 100,000 or one third as great

An examination of the chambers in this pyramid shows that many of the seams between blocks of stone are nearly invisible, and that there are no signs of settlement cracks or flaws One wonders whether any of our modern structures will survive 6,600 years in as perfect condition.

Flood control sounds like a modern problem, at which we have not done too well—witness the 1937 Mississippi River flood Herodotus, a Greek visiting Egypt in 430 B C, described a flood control and irrigation system in the Nile valley which was begun in 3400 B.C. This system contained a dam impounding a water area of 700 square miles connected to the Nile by canal, for regulation purposes The river valley land below this dam was divided into basins for holding the water until the silt used for fertilizer had settled out Villages were built on artificial mounds above flood level Instead of dreading floods the Egyptian farmer welcomed them, since the silt brought down by the flooding river was necessary for enriching the land

As I mentioned before, the Greeks were the first people to contribute largely to scientific and engineering theory By 200 B C plane and some solid geometry was pretty well worked out, the laws of levers and center of gravity understood, and something was known of relative density and hydrostatic pressure In fact, plane geometry was called Euclid, after the Greek scholar, until quite recently. Physics books now name the law of buoyancy after its Greek discoverer Archimedes. The Greeks also had some understanding of the arithmetical relations of musical tones and the laws of light reflection. Archimedes had determined the value of π, that is the ratio of the circumference of a circle to its diameter, to within 1 part in 10,000.

At the height of the Greek civilization, the great minds were almost entirely concerned with theorizing Practical applications of their new knowledge did not interest them, in fact, practical engineering was considered beneath their exalted station This attitude is not unknown at the present time As there was plenty of cheap slave labor to do the job required in the Greek world no need was felt for labor-saving or power-producing machinery. The building of automata, similar to our mechanically operated toys, was as near as these scholars cared to approach practical application, although they were not above loading dice with lead, as mentioned in the writings of Aristotle

With this background many interesting but non-productive devices were built Greeks used water trickling through a small hole into a reservoir as a measure of time These timepieces had many ingenious variations such as a form of alarm clock attributed to Plato. In this device a second closed reservoir was connected to the first by means of a siphon which would not become charged until the water in the first reservoir had reached a predetermined height The siphon would then quickly draw off the water from the first reservoir to the second, forcing air out of the second reservoir through a whistle in the cover There is a mechanically operated puppet theater described, which is a good example of an automaton, built to mystify the common people This device consisted of a closed box set on wheels running in tracks laid on a stage. On top of the box was a small temple surrounded by figures of dancing girls and containing an image of Bacchus The device

moved onto the stage under its own power while Bacchus poured libations and the figurines danced. At the conclusion of the performance the wheel-driving mechanism reversed, moving the entire show off of the stage. Power for this contrivance was obtained from a falling weight hidden in the box and controlled in speed by a device similar to a water clock, but using millet seed instead of water

When necessary the Greek scholars could do outstanding engineering work Archimedes was drafted for the defense of his native Syracuse against the Roman fleet and armies The historian Polybius describes several of Archimedes' new devices designed for the destruction of the Roman galleys operating under the city walls One employed a heavy lead ball, suspended by a pulley arrangement from a long arm, which could be swung about and dropped on the galleys' decks Another device suspended a grab hook from a crane arm in such a way that the hook could catch the bows of the Roman ships, lifting and suddenly releasing them, causing a "scene of the utmost confusion," to use a phrase from our historian

At the end of the pre-Christian era we find more attention paid to practical devices containing the so-called modern machine elements such as wedges, jack-screws, pulleys, windlasses, levers, toothed gearing, etc Compressed air and hydraulic devices such as force pumps, siphons and pipe organs were known also Hero or Heron, an Alexandrian engineer, describes several useful machines, among them a hodometer similar to our bicycle odometers Hero's device, when mounted on a wagon, converted the revolutions of the wagon wheels, through suitable step-down worm gearing, to distance traveled, and showed this distance on a calibrated dial For use as a taximeter, metal balls were arranged to be dropped by the machine into a resonant container, thus marking the completion of each unit distance of travel with a suitable noise.

Hero also describes a two-cylinder water pressure pump for fire extinguishing, fitted with a nozzle capable of pointing in any direction Remains of pumps similar to this have been found, made of wood with lead-lined cylinders Other two-cylinder pumps, made entirely of bronze, have been recovered The pump valve designs are quite satisfactory for modern use

Hero is credited with a device resembling a reaction steam turbine He mounted a hollow bronze ball on pivots between two uprights above a heated closed vessel containing water, that is, a boiler One upright and pivot was made hollow so that steam could be led from the boiler into the hollow ball This steam escaping from two bent nozzles on the ball rotated the ball Since power could be cheaply obtained from slave labor this device was looked upon as an interesting toy rather than a source of useful power It wasn't until seventeen centuries later that men became seriously interested in using steam for power purposes

Hero's surveying instrument, the dioptra, contained all the essential movements of the modern transit without its telescope A water level with a long base built into this instrument gave accurate leveling The familiar surveyor's staff with movable sighting disk was used in its present form

On the water the ancients got around quite well About 600 B.C. the Phoenicians circumnavigated Africa. Later there was a canal from the Nile to the Gulf of Suez serving the same purpose as the present Suez Canal. Apparently the ancients were troubled with some of the same problems which our modern naval architects face The early boats on the Nile were built with long, overhanging bows and sterns. To prevent

sagging of these portions a truss of twisted cable was passed from the bow over several short uprights set along the length of the boat and again fastened at the stern This anti-hogging device can be seen on some modern river steamboats as a steel rod with turnbuckles placed exactly as in the Egyptian boats

In the Mediterranean the Greek and Roman war galleys could attain speeds of 13 to 15 knots for short times and average 7 knots on long voyages In maneuverability these galleys have never been surpassed Again man power was used to propel these vessels since it was easily obtained and controlled Only on long voyages with favorable winds or in merchant vessels were sails employed

Some of the ancient ships were rather large, a galley built for Ptolemy Philopater of Egypt was reported to measure 420 feet long on a beam of 57 feet A dry dock complete with movable gates, valves, pumps and keel blocks, is described for handling this mighty ship

There are many more instances of the ancient use of modern discoveries and reinventions Theophrastus (third century B C) describes coal and its combustion Dioscorides (first century A D) mentions the distillation of crude mineral oil to obtain different grades of oil Apparently our modern petroleum industry began its development at least 1,900 years ago We think that certainly our chewing gum and cigarette vending machines must be new, but Hero describes a device for dispensing ceremonial water in Egyptian temples, operated by putting money in a slot The advantage of the ancient device over ours was that the exact coins were not needed, since the machines delivered when the correct total weight in coins had been provided

Ingenious and modern-sounding as many of these early devices are, they differ from our modern engineering projects in that they take no account of power The ancients employed cheap and easily available slave labor, which could produce about one tenth horsepower per head While this system was all right for the ruling classes, for the slaves themselves it meant untold labor and suffering Great as have been our advances in science and engineering, they are more than paralleled by our social advancement And perhaps the ancient engineers, if they could come to life today, would be most surprised to see us using, instead of a sweating and groaning slave, his power equivalent of 75 watts of electricity, which most of us can buy at the rate of two fifths of a cent an hour

BAKING TECHNOLOGY AND NATIONAL NUTRITION

By Dr. JAMES A. TOBEY
AMERICAN INSTITUTE OF BAKING

BAKING has been an art since the dawn of civilization, for bread is the most venerable of the prepared foods of man In every era of harried human existence, the race has been nurtured, biologically if not spiritually, on bread alone Thus, bread has come to be an appropriate symbol for food itself.

It is an apt symbol, because bread gives sustenance that satisfies certain important physiological needs While it is axiomatic that there is no substitute in the human diet for pure milk, foremost of our protective foods, it can be asserted with equal scientific validity that there is no substitute for good bread, foremost of the foods that give energy Research has amply demonstrated, in fact, that the most beneficial diets are usually those that are built around bread and milk

From a craft, baking has been emerging in recent years into a science. There has been developing a new baking technology, based on the application of scientific methods and principles to the age-long art of bread-making The progress of this new technology is, of course, far from complete, but already its results have had a definite influence on our national nutrition

The future influence of baking technology will depend not only upon the significance of new discoveries and procedures, but upon their avid application by the baker and, most of all, upon the ability with which they are interpreted to the consumer In any branch of technology, interpretation is always as important as investigation and application.

THE SCOPE OF BAKING TECHNOLOGY

Baking technology begins not in the bake shop or the mill, but on the farm and in the soil where wheat, the aristocrat of the cereals, is produced It is to the cereal chemist that we must look for the first step in the ultimate manufacture of the perfect loaf of bread Where the cereal chemist leaves off, the bakery engineer begins, although the line of demarcation between the responsibilities of the two is sometimes difficult to define.

The cereal chemist is concerned primarily with the properties of flour, the principal ingredient of bread and baked goods In most instances he is a laboratory technician, remote from the consumer It was suggested by L E. Caster at the 1938 meeting of the American Association of Cereal Chemists that most cereal chemists would perform more valuable functions if they spent considerable time in the operating end of bakery production.

"Cereal chemistry," said Mr Caster, a former president of the American Society of Bakery Engineers, "is still in the pioneering stage The chemist has been prone to tackle his problems from a pure chemistry standpoint and has forgotten that flour is a biological, living material which changes from day to day. In order, therefore, to be of assistance to the production man, the chemist must realize that he, in the laboratory, must deal with flour and bread just as they are produced and used, not for the purpose of running his chemical determinations "[1]

[1] L E Caster, *Am. Baking Asn. Mo. Bull.*, May–June, 1938

The problems of baking technology are accentuated by the fact that wheat and the flours made from it in different years and in different places seldom show any degree of uniformity. These variations are due to certain uncontrollable factors, such as climate and weather, but they are also due to some controllable factors, such as soil chemistry, plant genetics and methods of harvesting The miller is cognizant of these problems and cooperates with the baker in attempting to solve them.

Modern Bread

Modern bread is, however, more than wheat flour A quarter of a century ago, bread was made largely in the home from wheat flour, salt and water, fermented with homemade yeast of somewhat uncertain quality. To-day, about 85 per cent of all bread consumed in the United States is prepared by approximately 28,000 commercial bakers The formulas employed by these bakers not only are different from those formerly used in the home, but they are better, and here is one important advance in baking technology

In addition to wheat flour, the modern baker of white bread also includes milk solids, pure yeast of uniform quality, some kind of shortening or fat, salt, sugar in the form of sucrose or dextrose, malt or malt extract and water Where local water supplies are too soft, he may add very small amounts of certain calcium salts as dough conditioners Because of the richness of his formula in other ingredients, the baker uses slightly less flour than was once the custom The resulting improvement in the quality of the loaf tends, however, to increase rather than decrease flour consumption

Perhaps the most significant change in the formula of modern white bread has been the inclusion of increasing amounts of milk solids, derived from whole or defatted liquid milk, condensed milk or powdered milk. The growth in the use of milk in bread is indicated by the fact that in 1923, when the American Institute of Baking took the initiative in advocating more milk in bread, the baking industry purchased 33,000,000 pounds of dried skimmed milk, as it was then called. To-day, bakers buy more than three times that quantity of "dry milk solids not over 1½ per cent fat," as the product is now more aptly designated The baking industry is, in fact, the largest single customer of the dairy industry, procuring annually from it the equivalent of a quarter of a billion quarts of milk

The addition of milk solids to bread is important from both the standpoints of baking technology and dietary quality. The use of milk in bread unquestionably improves its color, texture, symmetry and general quality, without appreciably affecting the cost per pound The milk contributes complete proteins, which supplement the nutritive properties of the wheat proteins, glutenin and gliadin. Bread made with milk has, in fact, about 10 per cent protein, which contains all the amino acids now recognized as indispensable to life

Milk solids likewise contribute the important food minerals, calcium and phosphorus, to bread The presence of these minerals in white bread is further augmented by the use of calcium salts as dough conditioners or so-called yeast foods. Modern bread is, in fact, a much better source of calcium than published analyses of the past would indicate Recent investigations by Cathcart and Prouty in the laboratories of the American Institute of Baking at Chicago have shown that commercial loaves of bread will average 065 per cent calcium[2] Thus, six slices of bread a day will furnish 30 per cent of the calcium requirements of the normal adult. A pint of

[2] *Jour of Nutrition* In press

milk in the diet would supply the remainder.

The use of an average of 6 per cent. milk solids in white bread has served likewise to make even more ridiculous and absurd the rantings and ravings of the food faddists who wax so frenetic over the alleged virtues of whole wheat products and the supposed deficiencies of white bread. The routine addition of milk to white bread (except French and Italian bread) has so narrowed the nutritional gap between this nourishing food and the coarser-grained dark breads that the only dietary advantages now recognized for whole wheat bread are the higher contents of iron and vitamin B_1 or thiamin. The higher contents of these nutrients are offset somewhat by the fact that whole wheat products also contain a large amount of indigestible, unassimilable fiber or roughage. Bran may be a boon to a few sufferers from chronic bowel dyskinesia, or constipation, but for many persons it is a dangerous irritant in the gastro-intestinal tract.

Restoring Lost Nutrients to White Bread

White bread made with milk is a fairly good source of vitamin B_2 or riboflavin, but it contains only from one fifth to one fourth the usual thiamin or vitamin B_1 content of whole wheat bread. Since this important factor is frequently deficient in the average American diet, its preservation in refined flour and white bread or its restoration to these products would be eminently desirable. Despite the ardent pleas of nutritionists for a greater consumption of the whole grain products, the American public always has preferred white bread and continues to espouse it, chiefly because of its bland flavor and more attractive appearance. Only about 2 per cent. of all wheat flour now consumed in this country is of the whole wheat variety, and there seems to be little likelihood of any drastic increase.

Modern baking technology has developed effective methods for the retention of thiamin in white bread, although these procedures are not yet in universal use. Thus, new methods of milling are reported as preserving the original content of vitamin B_1 in white flour. Ingredients rich in this factor, such as yeast, have also been placed on the market, and there are available various concentrates of the vitamin that can be added to the dough. Since thiamin is thermostable, there is no appreciable loss of it in baking.

Here, then, is an opportunity for the baking industry to improve still further the nutritive qualities of the staff of life. Once these methods of restoring a lost vitamin to bread are on a satisfactory economical basis, they deserve wide adoption. Such methods will not make bread a perfect food, but they will enhance its dietary values.

Research in the Baking Industry

Since the baking industry is a local service industry, comprised of a large number of small companies, and since there are relatively few big concerns with adequate facilities for laboratory investigations, research in the field of baking technology is primarily the duty of the organized industry itself. Such research is undertaken by the American Institute of Baking, the scientific and educational agency of this food industry, at its laboratories in Chicago.

Among the important problems that have received attention and are now being investigated are improvement of the quality of the loaf through the use of baking pans of proper dimensions, the prevention or postponement of the apparently inevitable staling of bread, the improvement of bread flavor; the sanitary protection of custard and cream-filled baked goods by pasteurization and other methods; the chemical and physical

properties of dough; the cooling and wrapping of bread; photo-electric methods for determining the characteristics and quality of bread crumb; and means of scoring and tasting bread[3]

A recent advancement in the laboratories of the American Institute of Baking has been the development of a successful process of preserving bread by freezing[4] While this device has not yet received much practical application in ordinary commercial usage, it is being considered for such purposes, and the process might assume real importance in time of war

In addition to the studies on baking technology conducted by the institute itself under the able direction of Dr W H Cathcart, the department of nutrition of the American Institute of Baking has made available grants for research fellowships at leading universities for studies on the nutritional aspects of bread and bakery products Such fellowships have been established at the Massachusetts Institute of Technology under Professor S C Prescott, and at Columbia University under the direction of Professor Henry C Sherman These ivestigations and others of a similar nature will be concerned with the chemical, biochemical and biological properties of bread and their influence on human nutrition

Bread in National Nutrition

The improvements in the dietary and gustatory qualities of bread and bakery products that have been achieved and are being accomplished are of distinct significance to our national nutrition As a necessary foundation for the protective foods, the energy-giving food, bread, may properly constitute as much as 40 per cent of the calories in a well-balanced daily diet

The amount of bread used in our national diet is, however, considerably below its normal and proper quota Although approximately ten billion loaves of bread are produced annually in this country, the people could advantageously consume fifteen billion loaves Such an increase not only would be sound according to the premises of the newer or newest knowledge of nutrition, but it would have far-reaching economic effects If, for example, every person in the United States consumed one extra slice of bread a day, it would require the production of an additional 9,000,000 barrels of flour every year, and the problem of the wheat surplus would be solved

The nature of the American diet has been changing in recent years Some of these changes have been beneficial, while others have been detrimental The result is a national dietary that is superior to our fare of a generation ago, but is still below the accepted standards for adequate nutrition It does not even approach the optimal nutrition that is such a potent factor in buoyant health

Among the improvements in our national diet have been increases in the consumption of pure milk and other dairy products, and of fruits and vegetables, both fresh and canned Opposed to these favorable influences has been a tremendous increase in our use of raw sugar, from about 70 pounds per capita in 1900 to 110 pounds to-day Also opposed to the beneficial increments in some of the protective foods has been a decrease in the consumption of such valuable energy and tissue-building foods as bread, meat and potatoes

Recent surveys by government authorities have shown that the diet of the average American is frequently deficient in calcium, iron and vitamins A, B_1 and C[5] In order to overcome these defects, the daily diet of every normal person should

[3] W H Cathcart, *Am Baking Asn. Mo Bull*, March, 1938

[4] W. H. Cathcart and S. V Luber, *Ind and Eng Chem*, 31: 362, March, 1939

[5] H K Stiebeling and E F. Phipard, *Circ No. 507*, U S Dept Agr, January, 1939

be built around such protective and energy-giving foods as milk, bread and butter, eggs, fruits, green leafy vegetables, yellow and red vegetables, potatoes and meat.

In order to improve the American diet, there is necessary a substantial increase in our national consumption of pasteurized or certified milk and other dairy products, bread and cereals, fruits and vegetables, and meat and potatoes, with less emphasis on the pure carbohydrates that are devoid of minerals, proteins and vitamins

Good bread is the foundation of every well-balanced daily diet. Modern bread is superior to that of the past, and the bread of American bakers is now the best in the world Baking technology is constantly striving to improve the quality of bread and bakery products, and is succeeding in making them even better. The American baking industry recognizes its responsibilities as the purveyor of a wholesome nutritious commodity that is essential to the welfare of the people It proposes to discharge that responsibility to the best of its ability.

ARISTOTLE AND THE SCIENTIFIC METHOD

By RUFUS SUTER

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I

ONE who crosses the Charles River from Boston to Cambridge will see written across a building of the Massachusetts Institute of Technology the word. ARISTOTLE It is an extraordinary tribute to "The Philosopher," as Thomas Aquinas called him, that his name should still appear in the stone of a school representative of the most modern of modern cultures

The man of to-day, nevertheless, may have only a hazy notion of who Aristotle was He was the ancient Greek, everybody remembers, who misled the astronomers for centuries by lending his authority to the idea that the stars, sun and planets travel daily (as they seem to) round the earth He also blocked progress in physics, according to a common but historically inaccurate opinion, by championing the common-sense notion that freely falling bodies drop with a speed proportional to their weight This much, if we do not exaggerate, is the gist of the modern man's recollection of Aristotle But then why should his name be celebrated in the stone of the Massachusetts Institute of Technology?

If we are to resolve this curious paradox we must first recall that Aristotle was early. We are accustomed to think of the time separating us from 1610, when the greatest modern adversary of "The Philosopher," Galileo, pointed his telescope at Jupiter, as long The time is long, in a sense, for 1610 carries us before the United States, pendulum clocks and gas lights But the interval between 1939 and 1610 is only a few days in contrast with the lapse of time separating us from Aristotle Even the thirteenth century, when the Polos made their amazing journeys to Cathay and Thomas Aquinas effected the final synthesis of the Peripatetic philosophy with Christian revelation, is little less than a quarter of the period to the original Peripatetic We must travel before the beginnings of Islam, the preserver of the Aristotelian tradition when it was forgotten by the Europeans But even this era is a thousand years later than Aristotle. In our journey we must leave the Middle

Ages behind us; pass the wild years when the Goths were sweeping down out of the north and giving the final blow to the Roman Empire; pass the day when Jesus was born in Asia Minor, whose simple maxims were to be made tremendously recondite by their incorporation in the teachings of "The Prince of them that know," as "The Philosopher" was called by Dante We must pass some great names of Roman literature, like Cicero, who introduced Aristotelian philosophical terms into Latin, and thence into the modern languages derived from Latin: for instance, *species* from the Greek *eidos* We must, indeed, travel before the days when Rome was an empire At last we will come to Alexander the Great, the Macedonian who founded an empire before the glory that was Rome Alexander in his boyhood was the pupil of Aristotle

We have sketched this outline of some outstanding events in the past because we wished to make it vivid that Aristotle was early To appreciate this is important if we are to comprehend why he has dominated European thought He is to us what Confucius (if we may draw a parallel with the spiritual father of a people much discussed to-day) was to the Chinese. We have in both these men—Aristotle and Confucius—instructive examples of powerful intellects flourishing at the beginnings of civilizations, and thus able to be the fountainheads from which subsequent culture flowed.

The contrast between Aristotle and Confucius is also instructive In the oriental sage we find the archetype of a cast of mind often characteristic of the grave, ceremonious literati of China Frequently holders of official position, they tended, like most serious men whose concern has been with the state, to regard the deepest knowledge as insight into morals, or as having its justification in the development of character.

This moralistic view of the nature and use of knowledge is also to be found in Aristotle The noblest man is he who understands and habitually practices the virtues But in the thought of the Greek philosopher is a type of knowledge nobler, as it were, than the noblest. This activity has no connection with morals, the state or society It does not derive its sanction from its capacity to develop character or citizenship. Here man, forgetting himself and his political and economic problems, broods over a reality essentially non-human In this impractical turn to the Aristotelian mood, the west found her justification for concern with questions unrelated to the welfare of the human-race The commentators on "The Philosopher" could investigate reality for theoretical reasons, and remain respectable citizens

Another instructive contrast between the Greek thinker and Confucius is that the impetus which each man gave his respective civilization has led in different directions The Confucian Classics are recensions of earlier works dealing mostly with history, ritual, political and social science and ethics The resultant intellectual tradition has, accordingly, been humanistic The technique of textual criticism was elaborated to a fine point, but aside from this the concern with the Confucian Classics of many generations of scholars gave birth to no consciousness of the scientific method

Aristotle's contribution to the world, on the other hand, was his awareness of inference This was a startlingly original appreciation, nor can one admire too strongly the mind which first became fully self-conscious here To see clearly, for example, in the abstract, that if x is y, and z is x, then z is y, is a stroke of genius The insight was as remarkable as that of the man who first saw, in the abstract, that $2+2=4$ The word "syllogism," in fact, given by Aristotle

to his three-step brand of inference, is the Greek equivalent of the Latin "computo", but whereas "to compute" has come to mean "to think together" numbers or letters standing for them, "syllogism" is used exclusively for the "thinking together" of concepts such as "man" or "mortal," or letters or other symbols representing them. In Aristotle's appreciation is contained the notion of logical system

We now have two hints of why Aristotle prepared the way for the birth and growth of science. The authority of his example made socially permissible a disinterested interest in the universe, an interest unprompted by political, social, religious or ethical bias, and under his tutelage the generations of scholars became more and more devoted to the ideal of thinking systematically

We have, on the one hand, starting with "The Philosopher," the notion that pure science, science preoccupied with reality for its own sake, is worthy of the best type of intellect, and we have, on the other hand, also starting with "The Philosopher," the idea that genuine knowledge must be systematic Now if we remember that for centuries, indeed until the consciousness of the scientific method fully dawned upon Europe with the advent of Galileo, the function of students was to mull over the Aristotelian writings (as, for centuries, the business of the scholars in China was to comment on the Confucian Classics) we will not be surpised that Aristotle moulded the western mind

II

The nerve of our argument is that practise in thinking systematically was a condition of science This is rarely noted to-day because we usually think of the scientific method in only one of its aspects: its empiricism, the importance of which was taught to us by Galileo We tend to set it in contrast to the syllogizing, highly systematic mode of thought of our medieval ancestors. This lack of emphasis, however, is a case of the common failure to see the obvious. Before concluding we must make clear why the factor of system was as essential to science as the factor of experiment and observation

Even the most distasteful to us of the activities of the medieval schoolmen—their indefatigable logic-chopping—had its value It afforded experience in a heroic effort to get all knowledge into such shape that the propositions containing it could be seen to be interconnected in the way of premises and conclusions But this form of thought (and this is what we wish to emphasize), if it is not to be hallucination, must presuppose a certain view about the form of the universe, the object which thought is assumed to fit The world itself, in other words, must be systematic If the syllogism x is y, z is x, therefore z is y, is valid reasoning, and if valid reasoning is to hold true of nature, then granted that x *is* y, in the world, and that z *is* x, z must also be y in the world For example if all stars are suns, and if Arcturus is a star, then Arcturus is a sun, not only as a matter of valid reasoning for thought, but also as a matter of scientific fact in the universe

Here we have shown that logically, if reasoning is to hold true of nature, nature must be conceived as fitting into the pattern of reasoning But what is important for our purposes is not this logical point, interesting as it is, but rather a historical point The recognition among the Peripatetics that the world is orderly came historically as a result of their concern with the systematic character of thought Nature, except in very broad outlines, does not impress us at first with her orderliness. Instead she seems, more often than not,

fitful, arbitrary, unintelligible She has appeared to man, in the remote past, as a kind of other-self, or other-will, opposing his own, and as irrational as he. For ages, perhaps, anthropomorphic qualities—desire to thwart, benevolence, unfairness, justice—were more naturally attributed to her than the utterly dehumanized character of abstract system. Hence it was not insight into the orderliness of external reality which produced in the worshippers of Aristotle the idea that thought must be systematic It was, instead, the centuries of logic-chopping, inspired by "The Philosopher," which made the idea that the universe is orderly gradually become instinctive to the western mind.

It may seem ridiculous that so inescapable a pattern as the syllogism should imply anything significant about reality It is as if we should say that since we can conclude from "No circles are squares" that therefore "No squares are circles," we know something important about order in nature The fact is that even from such pre-syllogistic types of inference, we can conclude something important Granted that the syllogism is utterly, obviously inescapable—as inescapable as this instance of immediate inference we have given, that the world is describable by it nonetheless signifies order, an inescapable order, if you like, but still order It is to the credit of the Peripatetics that they educated Europe to this harmless, indubitably true, absurdly basic conception of the orderliness of nature Here is the ground uprooted of all superstition, of all mystical ornamentation, of all religious and sociological bias, indeed of all specific and possibly disconcerting or irrelevant content whatsoever, in which the seed of empiricism, once Galileo had planted it, could take root and grow into the fully blooming scientific method If the acutest scientists had deliberately planned the history of thought to make it finally productive of the scientific method, they could not have done better

It is important that we grasp the immense value for science of this bare, non-committal, inescapable character of the orderliness of nature which was reflected from the syllogism Other brands of orderliness are conceivable, and indeed have held sway over the minds of men for long periods That they have been barren in so far as the production of scientific method is concerned, even during ages when men knew how to observe and experiment, was invariably because they included some reference to an irrelevant element which misled the minds of the investigators For instance, men have supposed that the events on the earth were the result of events in the sky—new stars, solar and lunar eclipses, meteors and comets Again they have imagined that the happenings and features of natural objects and living creatures in the world are symbols of various moral concepts and of ideals in the mind of God Likewise they have made innumerable attempts to explain the phenomena of nature through ingenious but arbitrary parallelisms, such as that the number 5 is significant, and that therefore there are 5 elements, 5 planets, 5 directions, 5 virtues, 5 openings in the face, etc All these schematisms, although they provide system in a sense, were too specific They could, in some cases, under the creative power of extraordinarily brilliant minds, produce excellent mythology, cosmic epic poetry, rules of conduct and statutes to guarantee the permanency of the state, but they could not produce science The scientific method required a premise in which nothing specific was asserted about the way in which the orderliness of nature expresses itself. The discovery of the way must be left to the researches of the observers and experimenters, who had

no axe—save curiosity—to grind. All that could be assumed beforehand was the fact of orderliness; and this the syllogism was able to reflect, since its form *is* order.

We could also mention here—if the consideration did not lead us too far afield—that the form reflected into nature from the syllogism is simpler and more basic than the order arising from the idea of the relation of cause and effect, at any rate in some meanings of "cause" and "effect." These concepts easily become as specific as the pre-scientific notions of order we have listed. That causality is a "push," an effort, an expenditure of energy, for example, is not unlike the notion that order is a symbol of a virtue. The difference is that the former theory has as its context a mechanistic mythology, whereas the latter has as its context a theological mythology The former theory, although for a while it actually was helpful to science, eventually became a liability But this consideration is beyond our present scope. What is important for us to remember is that the conception of order prolific for science was merely the conception of order, and nothing more.

In conclusion we must say a word about the relation of pure science, the disinterested curiosity to lay bare the specific embodiments of system in nature, to applied science. The Massachusetts Institute of Technology descends from Aristotle. This was our thesis. But thus far we have only been busied with showing that the possibility of pure science was conditioned in part by centuries of mulling over the systematic Aristotelian philosophy, whereas the Massachusetts Institute of Technology is a monument to applied science. The transition is easy. Once a law of nature is exposed, some practical man is certain to perceive its relevance to engineering. The practical application is naturally the final step in intellectual movement, where practical application is conceived as a large, wholesale, far-sighted, deliberate process, as it is for modern industrial science

Thus, last is the Massachusetts Institute of Technology. Earlier is the brilliant age of dawning pure science: the period of Newton, Boyle, Galileo, Kepler Earlier still is the preparatory era· the age of scholasticism and of its Peripatetic precursors in Islam and the late Roman Empire. Then, first is Aristotle.

BOOKS ON SCIENCE FOR LAYMEN

GONE WITH WIND AND WATER[1]

WE have here a thorough scrutiny of the problem of soil erosion on all continents The authors, both British, are competent professional students of soil They are also, like large numbers of their scientific colleagues in the British Isles, keenly aware of the social implications and responsibilities of science. So far as their political attitude comes to light, it is unsentimental. Yet nothing more deeply disturbing than this book, even among American writings on soil erosion, has appeared

The factual account of soil destruction, continent by continent, is reenforced by a picture of its effect on the lives of human beings. No doubt remains regarding the operation of soil erosion as a major factor in human history And the reader, after learning of the situation in Africa, Australia, Asia and the Americas, has little trouble in agreeing that man is in for a race against time to preserve one of the foundations of his social structure. Correctly, the world-wide mischief is attributed to the exploitation which has accompanied the flowering of western Europe, itself largely immune to the worse types of soil erosion Incidentally, it is the reviewer's opinion that one can not understand the present plight of Europe itself without considering it a vast metropolis which for three hundred years has utilized the rest of the world as hinterland

Less accurate, perhaps, is the authors' statement that the mischief is due to the spread of a system of land use which worked well enough under European conditions, but which could not work elsewhere In effect, the authors elsewhere qualify this statement, yet it is a clue to the least satisfactory phase of their report For they quite ignore the contrast between Teutonic patterns of land use and management in this country and those of British origin. The former have generally resulted in a minimum of destruction, the latter have been highly exploitive and dangerous One of the most practical approaches to our problem here lies in a study of the many communities, largely German, Dutch and Scandinavian, in which a well-balanced relation has been maintained for long periods of time The picture is black enough, God knows, but not wholly so.

Students of population problems will search in vain for suggestions of improvement through birth-control While admitting that erosion arises from population pressure, the authors insist that hope lies in still more acute pressure of this sort, enforcing respect for land Japan and Java are cited as examples The reviewer must beg to remain not wholly convinced, quite apart from the question of wars and other social conflicts which attend readjustments through sheer human pressure

Of particular interest is the discussion of political and social consequences with which Mr Jacks concludes the volume. For Africa, a humane type of feudalism, with the blacks anchored to the land under white supervision, is suggested Much is made, and rightly, of the resemblances and contrasts between Russia and the United States The authors are convinced of the growing need for collectivism everywhere. On the whole, they seem inclined to prefer the rather blundering and deliberate democratic approach, which is getting under way here, to the more violent and Utopian pattern in Soviet Russia.

The technological improvements which have been developed, largely in this country, are discussed intelligently and in

[1] *Vanishing Lands* By R. O. Whyte and G V Jacks. Illustrated. xvi+332 pp. $4.00. Doubleday, Doran and Company.

considerable detail The role of education, however, is passed, except in connection with the proposed new feudalism for Africa, and one misses the name of Hugh Bennett, apostle of conservation, in the index After all, the American way of living is remarkably flexible in meeting emergencies, once the people are made to understand that emergency exists Public information is a most vital link in erosion control.

There is a growing group, both among extreme radicals and their mortal enemies, the industrialists, which might be called Neo-scientist Tacitly it is assumed to speak for all scientists This group pins faith on the multiplication of inventions and devices and builds on the Marxian idea that rural life is a form of folly and urban comfort the only wisdom In contrast, this book starts squarely on the assumption that soil is the basis of civilized life, and that human ecology, as a source of perspective, is one of the most urgent needs of mankind By inference, conservation is less a technique than an attitude

The struggle between those who would live with the soil and those who would live off of it is perennial in human history, nor is it by any means nearly at an end Meanwhile we are obliged to agree with the authors of this important book that the present emphasis on nationalism is not wholly a curse, for it is everywhere rubbing the soiled noses of men into the cleanly soil

PAUL B SEARS

CLASSICS OF GEOLOGY[1]

GEOLOGISTS frequently temper their confessions of ignorance with the statement that theirs is a young science If seekers for information reply by mentioning Avicenna (980–1037), Avempace (d 1138) and Leonardo (1452–1519), that argument seems to crumble. How can a science be young when its roots go back almost a thousand years?

[1] *A Source Book in Geology* By Kirtley F. Mather and Shirley L Mason xxii + 702 pp $5.00 McGraw Hill Book Company.

This book answers that question: the "roots" were no more than sporadic flashes which led to nothing. No one pursued Avicenna's outline of mountain building, Avempace touched upon the earth only incidentally, Leonardo's notebooks were not published until long after his death The fact that he had no immediate influence is shown by the lack of any sixteenth century writer who applied Leonardo's ideas concerning fossils, the salinity of the sea and sedimentation Indeed, the contributions of sixteenth and seventeenth century writers combined fill only 40 pages in this volume, while those of eighteenth-century workers fill 117 pages The remainder of the book (524 pages) traces the growth and specialization of earth science during the nineteenth century

This means that geology, as geology, is barely 140 years old In spite of this, some of its most modern phases date back to early years Thus Sir James Hall studied molten rock in the laboratory before 1805 and made marble in 1811 or 1812 Nicol described his well-known prism for the microscope in 1829, and James Hall of Albany advanced the concept of geosynclines in 1857 Even the planetesimal hypothesis, which has barely begun to displace Laplaceism in popular thought, was clearly stated by Chamberlin and Moulton almost 35 years ago

These are a few of the high lights in a book which, in itself, presents the high lights of published geology during four centuries A total of 126 authors are presented—some through papers which have been forgotten, even though their substance appears in almost every geologic text-book. Outstanding examples are Babbage's account of the temple of Jupiter Serapis and G P Marsh's discussion of the relationship between deforestation and floods Even more significant is Agassiz's summary of evidence for a glacial age, translated from a book published while he was professor at Neuchâtel

In short, this "Source Book" presents

a detailed, as well as a well-rounded, survey of a relatively new science that already has forgotten much of its history By bringing important yet relatively obscure papers to light, it also provides materials for histories of geology that are yet to be written.

C L F

THE ORIGIN OF LIFE[1]

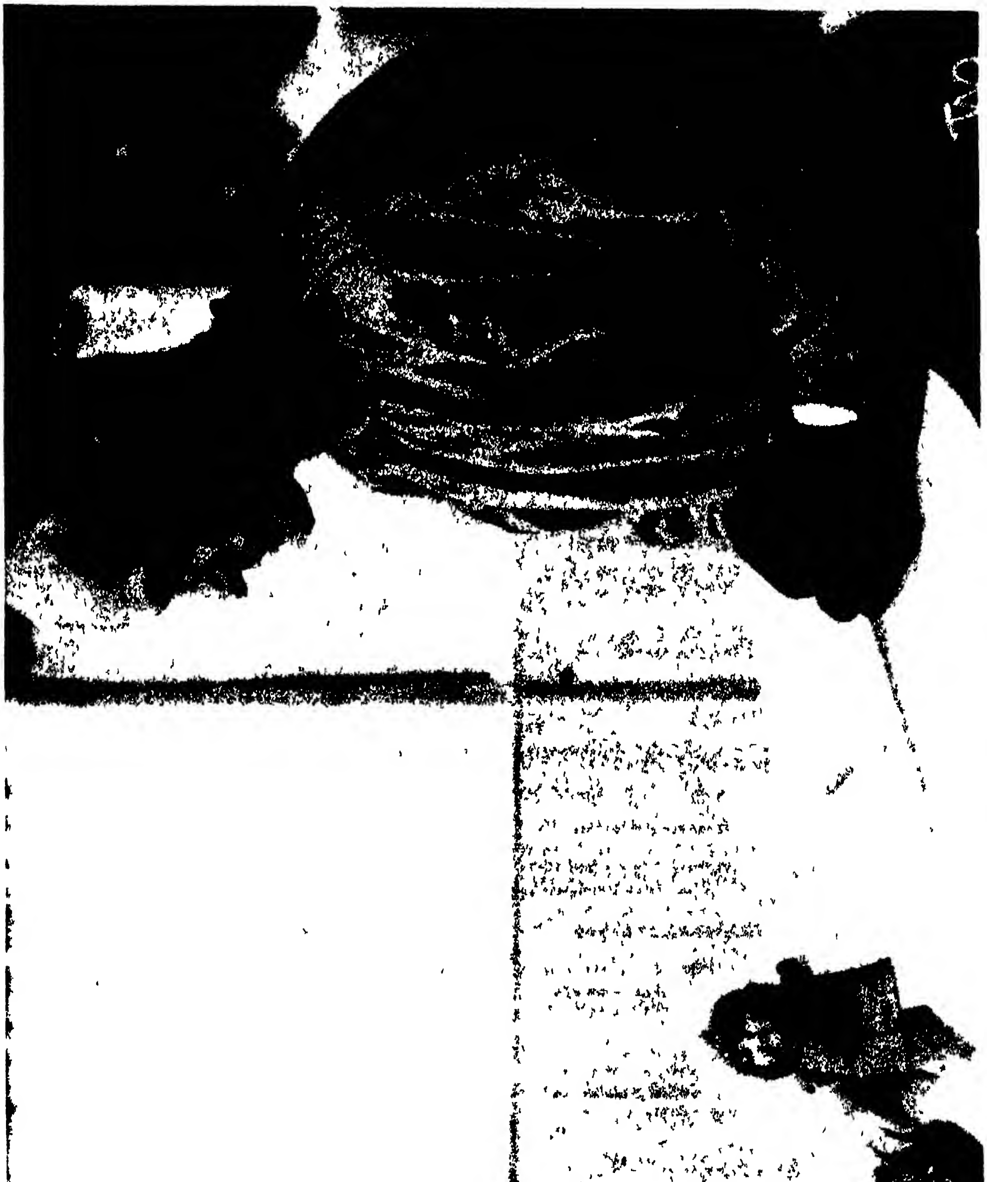
THE book, which is devoted to a description of studies of artificial non-living systems showing a faint resemblance to accepted living organisms, is divided into four sections, the opening one of which is called "The First Approach Vital Growth and Crystallization" The forces involved in crystallization have long interested both scientists and laymen and are invariably invoked whenever life processes are under discussion, hence, they may rightfully be included in the subject-matter of a book on the origin of life The author compares the growth of crystals with that of organisms and concludes that the two have common features Unfortunately, emphasis has been placed on a description of the many forms which may result from the forces of crystallization, and but little is said concerning the nature of the forces and their possible rôle in life processes

The second section, titled, "The Second Approach Life, Carbon's Outstanding Property," is concerned with the development of chemistry, some elementary chemical facts and some of the recent chemical work on viruses There is included a two-page discussion of the origin of life on the earth and a ten-page survey of Oparin's book entitled "The Origin of Life" The ideas expressed by the author and by Oparin are very similar and appear to differ in only one fundamental point It is stated that "the essential feature of Oparin's hypothesis is that structural units with a remote resemblance to living organisms were *first* formed from the organic matter of the early ocean and that subsequently enzymes formed in them . ," whereas the author expresses the view "that the life-producing enzymes were the first to appear, through the action of electric discharges, without any structure around them—as self-regenerative enzymes Later only, a structure was built up around them " The latter are assumed to have properties somewhat similar to those ascribed to viruses, and the recent work on the isolation of certain viruses in the form of high molecular weight nucleoproteins is cited as evidence for the probability of such a sequence of events In view of the important rôle played by viruses in the author's theory, it would have been well to have included a short exposition of the view-point held by many that viruses arose not abiogenetically but from living organisms by some degradatory process Furthermore, the emphasis which is placed upon the carbon compounds could have been concentrated on the protein molecule with greater propriety

In the third section entitled, "The Third Approach The Importance of Salt and Water for Life and Growth," the author shows how the blood of animals may have been developed in early evolution from the ocean, which he refers to as the cradle of life The last section, "The Fourth Approach The Animal a Machine," serves to describe various artificial systems which simulate in one way or another certain activities of living organisms As a whole the subject-matter of the book is not well integrated and there is much that is not relevant It is unfortunate that there are some misstatements which will probably irritate the scientist and mislead the layman The book is not so much a discussion of life's beginning on earth as it is a record of the author's extensive interests and experience, both as an experimenter and as a student of the literature, and as such it may be recommended to the interested reader

W M STANLEY

[1] *Life's Beginning on the Earth.* By R Beutner Illustrated x + 222 pp $3 00 Williams and Wilkins Company.



DR. CUSHING AND A YOUNG PATIENT—1928

THE PROGRESS OF SCIENCE

HARVEY CUSHING AN APPRECIATION

Harvey Cushing, renowned physician and neurological surgeon, came as the fourth in line of a New England family of doctors who had settled in the Western Reserve early in the last century Grandson of Erastus Cushing, M D (1802–1893), and son of Henry K Cushing, M D (1827–1910), Harvey Cushing was born in Cleveland, Ohio, on April 8, 1869, he received his B A degree from Yale College in 1891 and his M D degree from Harvard in 1895 After serving as surgical house pupil at the Massachusetts General Hospital under J. W Elliot during 1895–1896, he had four additional years of surgical training under William S Halsted, the professor of surgery at Johns Hopkins University He then spent a year in Europe, during which time he studied under the physiologist Hugo Kronecker at Berne and later under Charles Sherrington in Liverpool, in 1901 he returned to the United States to take up a surgical career at Johns Hopkins Called to Harvard in 1912, he assumed his duties in Boston as Moseley professor of surgery and surgeon-in-chief of the Peter Bent Brigham Hospital in 1913 Shortly after the beginning of the World War, he organized a surgical unit which he later took to France (March 18, 1916), where he stayed with one brief interruption until April, 1919 After his retirement from the Harvard chair in 1932, he came again to Yale to occupy a new Sterling professorship of neurology created for him in the School of Medicine, in 1937, he became professor emeritus and received the title of director of studies in the history of medicine

Harvey Cushing was widely known in three distinct capacities—as a great physician, as the founder of a school of neurosurgery and as a humanist of unusual literary attainment When his seventieth birthday was celebrated in April, 1939, the *New England Journal of Medicine* wrote in an editorial "The world at large will also be thinking of this great figure in American medicine, perhaps the foremost physician produced by the United States"

Dr Cushing prided himself upon being, first of all, a physician—a "good doctor" For him surgery was merely a form of therapy, and the primary responsibility of every man who entered the surgical field was to make himself at the outset thoroughly competent in the science as well as in the art of general medicine In this he took inspiration from the example of his distinguished teacher, William Osler, whose biography he ultimately prepared In clinical medicine, Cushing made many pioneer contributions He was one of the earliest in this country to appreciate the importance of the x-ray, his first scientific paper communicated to the Johns Hopkins Medical Society on May 3, 1897, being devoted to this subject He was also the first to introduce the use of blood-pressure determinations in the United States (1901), and was an early advocate of the importance of studying the basal metabolic rate Late in his clinical career (1932), he described a new clinical entity, "pituitary basophilism," which is now known eponymically as "Cushing's disease" In addition to making these individual advances, he was a life-long student of the diseases of the ductless glands, particularly those arising from disturbances of the pituitary body His monograph on the pituitary gland, published in 1912, has remained one of the classics of clinical medicine As a physician, he was a quick and penetrating observer, always preferring the evidence of the five senses to that obtained from instruments of pre-

cision, and his unfailing insistence upon the completeness of the case record earned him the epithet of "the physician of the written word" His case histories, even during his early days as interne at the Massachusetts General Hospital, were models of completeness, and where the written word failed in clarity it was supplemented by a skilful free-hand sketch, of which art Cushing was also an accomplished master On his seventieth birthday it was said of him that his soul, as well as his technique of life, was essentially that of an artist

Dr Cushing was more widely known in the world at large as the founder of a special field of surgery It is true that he created a school of neurological surgeons, and from the ends of the earth he attracted students who are now carrying on, in almost every country of the world, something of the high tradition which he had established But he did much more than establish a school of neurosurgery, for he also perpetuated and extended into the broader field of general surgery the traditions established by Halsted slow and painstaking dissection, gentle handling of tissues and the universal use of silk for closing wounds—all these things have become the creed and ritual of the Halsted-Cushing school which, by their pupils, especially those of Cushing, have been carried into every phase of surgical endeavor. In the field of his special interest, the surgery of the nervous system, to which he devoted time and attention over a period of more than thirty years, Cushing introduced innumerable technical improvements These advances, culminating in the introduction of the electrosurgical knife in 1927, made it possible for the surgeon to enter the human brain with as much confidence of success as the abdominal surgeon who enters the abdomen to remove an appendix The majority of these advances in cerebral surgery are, by common consent, due to the unremitting labor of Harvey Cushing alone; indeed, the procedures which he has introduced have been adopted wherever neurosurgery is practised His scientific contributions in this special field include important studies of the physiology of the pituitary, the classification and details of the life history of every form of cerebral tumor, and important observations upon the physiology of the human brain, the most notable of these being the description of the sensory concomitants experienced by conscious patients during stimulation of the post-central convolutions of the brain Cushing also did much toward clarifying various clinical entities caused by specific lesions of the nervous system, and he is credited with having crystallized many clinical syndromes of neurology

Finally, Cushing held high the traditions of the literary physician From William Osler he derived an abiding interest in the more cultural phases of medicine, medical history, medical art and in the origins of our medical institutions The art of writing never came easily to him, and his early papers can scarcely be looked upon as models of lucid exposition or fluent prose He "slaved" day and night over the shortest paper, and everything he published went through countless drafts; and by dint of this constant effort he acquired a literary style that was vivid, characteristic and distinguished His "Life of Sir William Osler" (1925) earned him the Pulitzer Prize for biography and some of his shorter literary papers, such as his appreciation of Welch on his eightieth birthday, and his Lister centenary address entitled "Emancipators" (1927), stand among the finest pieces of prose in our literature Throughout his career as a physician, Cushing retained a deep admiration for one of the fathers of the art, Andreas Vesalius, founder of modern anatomy For forty years he collected his works and his most recent literary endeavor was the compilation of an exhaustive bibliography of the Vesalian writings His last published work, how-

ever, was a warm-hearted and characteristically generous appreciation of his colleagues in the surgical art, Charles and William Mayo (*Science*, September 8)

Dr Cushing's library of medical and scientific classics, which has been bequeathed to the Yale University School of Medicine, is one of the finest ever brought together by a private person.

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YALE UNIVERSITY SCHOOL
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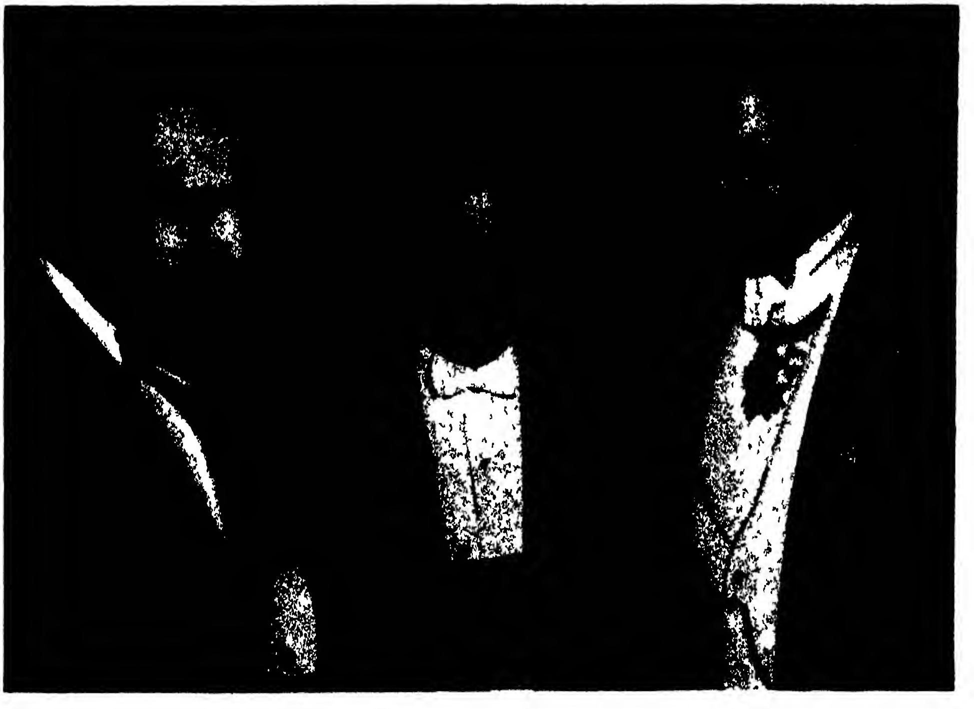
SEVENTH ASSEMBLY OF THE INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

DESPITE disturbed conditions abroad and the actual outbreak of war among certain of the adhering nations, the Seventh Assembly of the International Union of Geodesy and Geophysics convened in Washington from September 4 to 15, under the presidency of Dr D la Cour of Copenhagen, Denmark, with representatives of over 26 nations and a total registration of 537 delegates and guests, including 116 from foreign countries

At an early meeting of the executive committee, and after consultation with the State Department, it was decided that, with the large number of delegates already present and the great amount of material to be presented, the scientific aspects of the Seventh Assembly could proceed substantially according to the original schedule It was voted, however, in view of the fact that many persons could not be present and certain countries, therefore, were not adequately represented, that matters of administra-



DR D LA COUR, OF COPENHAGEN, PRESIDENT OF THE UNION (*RIGHT*)
Center HUGH WILSON WHO READ THE ADDRESS OF WELCOME FOR SECRETARY HULL *Left*, DR CLOYD H MARVIN, PRESIDENT OF GEORGE WASHINGTON UNIVERSITY

ATTENDING THE MEETING OF THE INTERNATIONAL UNION OF GEODESY
Left: CAPTAIN C L GARNER, OF THE UNITED STATES COAST AND GEODETIC SURVEY, CHAIRMAN OF THE COMMITTEE FOR ENTERTAINMENT *Right* DR ROSS G HARRISON, OF YALE UNIVERSITY, REPRESENTING THE NATIONAL RESEARCH COUNCIL

tion, finance and elections should be omitted and the entire attention given to the discussion of scientific matters

In opening the formal program, the introductory address was given by Dr Richard M Field, president of the American Geophysical Union, which was the official host for the Seventh Assembly of the International Union In his address, Dr. Field said in part

. The program of this Seventh Assembly now gathered in Washington concerns itself chiefly with those fundamental aspects of the sciences of the earth dealing with the problems of the earth's crust, its oceans and its atmosphere that can not be solved except by the cooperation of many nations to whom are entrusted various territories of our globe It is only through the acquisition of scientific information covering the entire surface of the globe that many of the basic problems underlying the dynamics of the earth and of its atmosphere can be solved

Following the opening remarks of President Field, an address of welcome by the Honorable Cordell Hull, Secretary of State, was read by the Honorable Hugh R Wilson, which in part was as follows

Your studies in the fields of seismology, volcanology, meteorology, terrestrial magnetism and electricity, oceanography and hydrology are of daily interest and importance not only to our governmental agencies responsible for official activities in those spheres but also to innumerable private organizations and individuals whose economic existence is dependent upon your efforts Millions of persons throughout the world owe in a large measure their comfort and livelihood to your notable contributions to the improvement of scientific aids to transportation by water, land and air, of building methods designed to minimize danger from earthquakes, of agricultural practices utilizing knowledge of surface and subterranean water supplies, of geophysical methods of prospecting and of the study of underground formations

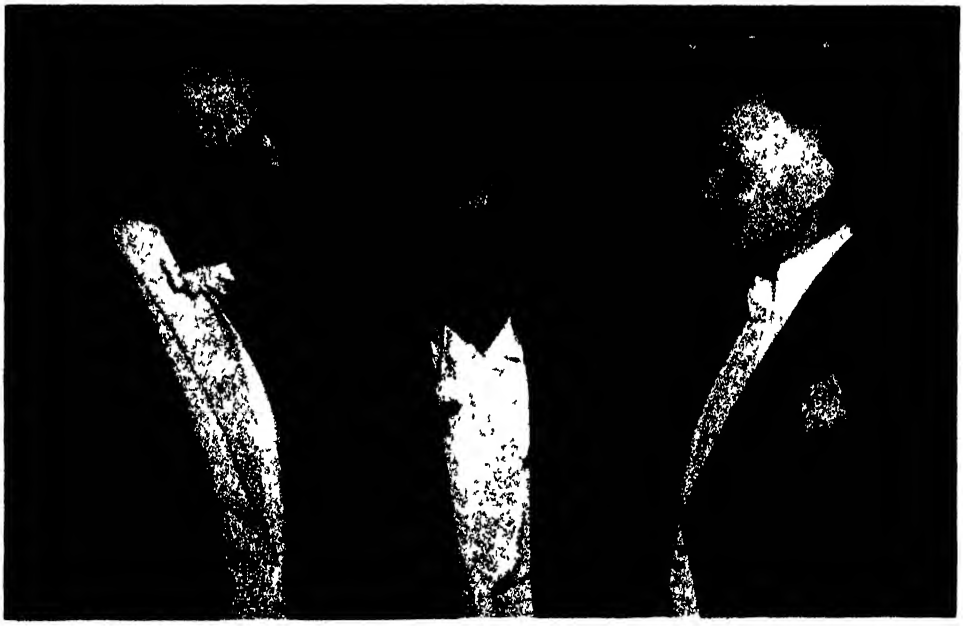
The response to the Secretary of State was made by Professor S Chapman, chairman of the British National Committee

A welcome on behalf of science was presented by Dr Frank B Jewett, president of the National Academy of Sciences. Significant among Dr Jewett's remarks are the following

Whatever the future has in store for the world and its inhabitants, it is, I think, safe to say that every increment to our store of real knowledge is potentially an increment added to a better way of life It may be a long way off, but the possibility of its attainment justifies our continuing the quest The field you represent is one of the most important in the whole domain because it is concerned with the very foundation on which all else rests

On behalf therefore not only of the National Academy of Sciences and of the National Research Council but of American science in its entirety I wish you an outstandingly successful conference

The general meetings of the associations were marked by the holding of many joint sessions at which important symposia dealing with fundamental problems of the earth and its atmosphere were presented The Association of Geodesy, for example, joined with the associations of Seismology, Meteorology, Physical Oceanography and Scientific Hydrology to discuss such basic problems as were presented in the report of the Commission on Continents and Ocean Basins The Association of Meteorology was joined with that of Terrestrial Magnetism and Electricity on September 8, at which the president of the Association of Meteorology, Professor S Chapman, delivered the presidential address on "Atmospheric Tides and Associated Phenomena" All the meetings of the Union emphasized the interpenetration of the work of the many associations, as specific



DELEGATES TO THE GEODESY UNION MEETING

Left to right DR WILLIAM BOWIE, OF WASHINGTON, ACTING SECRETARY-GENERAL OF THE INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS, DR R M STEWART, DIRECTOR OF THE DOMINION OBSERVATORY, OTTAWA, CANADA, AND DR. GUSTAF SLETTENMARK, OF STOCKHOLM, SWEDEN, VICE-PRESIDENT OF THE ASSOCIATION OF SCIENTIFIC HYDROLOGY

problems of the earth sciences invariably cross the fields of many workers in the conventionally departmentalized lines

The Commission on Continents and Ocean Basins attracted large numbers to its sessions, occupying three half-days of the Union's program A special session on tectonophysics attracted attention to a new and growing field of importance to all investigators in structural geology The uplift of land in Fennoscandia was presented by W Heiskanen, of Finland, and the derivations of the viscosity of the substrata were discussed by F Vening Meinesz The problem of the creep of rocks was presented from the experimental point of view by D Griggs, while the theoretical side of the same problem was outlined by R W Goransen The consideration of the flow of substrata in problems of earth deformation by B Gutenberg concluded this session

There were two distinguished lectures of general public interest The first, on "Round the World with Geodesy," was prepared by Brigadier H St John L Winterbotham, General Secretary of the Union, but was read by Dr William Bowie, ex-president of the International Union and General Secretary, *pro tem* The second, on "From the Mexican Gulf to the Arctic Sea—the Gulf Stream and Its Significance," was delivered by Dr Helland-Hansen, of the Geophysical Institute at Bergen, Norway

A special convocation was held at George Washington University on September 11, at which honorary degrees of doctor of science were conferred upon Dr D la Cour of Copenhagen, president of the International Union, and *in absentia* upon Brigadier H St John L Winterbotham

Excursions were conducted to the International Latitude Station at Gaithersburg, Maryland, the magnetic observatory of the U S Coast and Geodetic Survey at Cheltenham, Maryland, and to the Carnegie Institution's Geophysical Laboratory, and to the Department of Terrestrial Magnetism

An unusual feature of the assembly was the excellent exhibit of geophysical instruments, charts and models representing progress in geophysical exploration, which was arranged under the direction of Captain Paul Whitney

HARLAN T STETSON
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

THIRD INTERNATIONAL CONGRESS FOR MICROBIOLOGY

THE Third International Congress for Microbiology met in September in New York City, under the presidency of Dr Thomas M Rivers, director of the Hospital of the Rockefeller Institute In spite of the outbreak of hostilities abroad, which kept at home about one half of the 400 foreign scientists who had made their arrangements to come to New York, the meeting was acclaimed by those who were able to attend as notably successful and stimulating All agreed that it was a worthy successor to the first and second congresses, held in 1930 at Paris and in 1936 at London, which like the present congress, were organized under the auspices of the International Association of Microbiologists Largely responsible for the splendid spirit of the occasion was the determination of the foreign group not to let the anxieties of war interfere with the business of the congress

A plan of international scope was formulated with the object of preventing the recurrence of another world-wide outbreak of influenza, which attacked no less than one fifth of mankind during the last great war In the light of knowledge acquired during recent years on this worst of pestilences, it may not be too much to hope that another epidemic of influenza can be checked before it spreads beyond the country of its origin This will necessitate the closest cooperation

DR THOMAS M RIVERS

between workers in all countries, with the immediate distribution of the strain of virus responsible for the outbreak With this strain available, public health authorities will be in a position to institute preventive measures, such as vaccination, in which considerable progress was reported Of the many achievements of the Congress, the inauguration of this plan illustrates, perhaps better than any other, the importance for human welfare of letting nothing stop scientific investigation, and contrasts the international activities of the scientist with the nationalistic objectives of the politician

The official registration of the Congress was 1,624 Of this number, 250 were from abroad, representing 40 countries Over 800 were present to hear the welcoming addresses of Dr Rivers and of the Honorable Fiorello H La Guardia, Mayor of the City of New York Sir John C G Ledingham, director of the Lister Institute, London, who was president of the Second International Congress for Microbiology, responded on behalf of the official delegates from abroad Dr Lewis R Jones, professor emeritus of the University of Wisconsin, and Dr John L Rice, Commissioner of Health

for New York, also spoke On Monday evening the Rockefeller Institute entertained 850 at a delightful reception The final official social gathering was the banquet on Friday night, which was attended by 500 The addresses emphasized very well the international character of the occasion, for the speakers were representatives of 10 countries

The scientific program was divided into nine sections, which ran concurrently each morning for five days Several of the sections were so large that two divisions had to be held simultaneously In all, 625 papers were scheduled and approximately 475 were read, most of the remainder being cancelled because of the outbreak of war in Europe Three afternoons were also devoted to 40-minute lectures of a general nature by men distinguished in their respective fields They were presented by Dr B O Dodge (New York), Dr Paul Fildes (London; read for him by Sir John C G Ledingham), Professor J J van Loghem (Holland), Professor John R Marrack (London), Dr N H. Swellengrebel (Amsterdam), Dr W M Stanley (Princeton) and Professor Dr Arne Tiselius (Upsala) A colored motion picture, depicting the life-cycle of the woodtick, *Dermacentor andersoni*, which was made at the Rocky Mountain Spotted Fever Laboratory at Hamilton, Montana, by members of the United States Public Health Service, was shown on the final afternoon of the sessions

It is not possible to deal here in detail with any of the many papers given at the Congress It is feasible, however, to discuss the general trend of the scientific work presented This can be accomplished best by considering each of the nine sections separately

General Biology · Variation and Taxonomy (4 sessions, 51 papers scheduled) The discussion of the as yet unclassified, filterable microorganisms, including those of the pleuropneumonia group, was one of the most interesting of the Congress The study of these recently discovered organisms, which seem to fall between the bacteria and the filterable viruses, is rapidly yielding a new insight into bacterial enzyme-systems and their significance in parasitism. The complications which variation introduces into the classification of bacteria and fungi were also considered

General Biology: Microbiological Chemistry and Physiology (5 sessions, 64 papers scheduled) The entrance of the chemist into the field of bacteriology has led already to the accumulation of a vast amount of information on the metabolism of microorganisms, and the acceleration of activity in this borderland continues at a bewildering pace Bacteria lend themselves particularly well for investigations of the essential growth substances required by cells, and the knowledge of these bacterial "vitamins" is already of great importance in other fields, such as that of animal nutrition So, too, do bacteria provide a fine material for the investigation of enzymes

Viruses and Viral Diseases (9 sessions, 114 papers scheduled) Special interest was shown in the sessions dealing with the nature and characteristics of viruses, as revealed by the newer physical and chemical methods for analyzing their properties, with the relation of viruses to tumor formation, and with epidemiological studies of influenza Papers were also read on various plant and animal viral diseases, including the encephalitides, poliomyelitis, rabies, yellow fever and vaccinia

Rickettsiae and Rickettsial Diseases (2 sections, 21 papers scheduled) All phases of recent work in this active field were discussed, with particular interest manifested in the epidemiology, immunology and chemotherapy of rickettsial diseases

Protozoology and Parasitology (5 sessions, 60 papers scheduled) The mechanisms of immunity and resistance to protozoan and helminth infections occu-

pied the attention of two of the sessions, while the remainder of the program was devoted to a consideration of the parasites themselves, particularly to their life-cycles

Fungi and Fungous Diseases (7 sessions, 96 papers scheduled) The fact that plants suffer from a wide variety of bacterial, fungous and viral diseases, much as animals do, may come as something of a surprise to many people Nevertheless, such diseases are quite as important, perhaps more important in their total effect, than the more familiar infectious maladies of men and animals Indeed, much that is known of the relationship of infectious agent to host has been gained from the study of plant infections The sessions were devoted to a broad consideration of all aspects of the host-parasite relationship, from a survey of the growth substances required by the microorganisms to a consideration of the mechanisms of host resistance The subjects of sex, variation and genetics of the fungi were taken up at a special session

Medical and Veterinary Bacteriology (7 sessions, 85 papers scheduled) The study of animal diseases in their natural hosts, rather than the study of human diseases transferred to alien animal hosts, is the approach to the principles of infection and resistance which is so rapidly disclosing information of the greatest importance in both the medical and veterinary fields—hence the joint section Chemotherapy, naturally, received much attention. The ability to cure infection with some of the new chemicals now available is little short of miraculous Tuberculosis, syphilis and the other spirochaetoses, diphtheria, plague, enteric infections, wound infections and streptococcal infections came in for consideration

Agricultural and Industrial Microbiology (5 sessions, 68 papers scheduled) Various sessions were devoted to the microbiology of soil, to dairy bacteriology, to the bacteriology of water and sewage, to foodstuffs and food-spoilage and to fermentation, the activity of bacteria and fungi which underlies much of the great chemical industry

Immunology (5 sessions, 66 papers scheduled) Outstanding in the field of immunology has been the recognition of the complex factors involved in tissue immunity The volume of work on the complex chemical substances making up the multiple antigenic structure of microorganisms has been striking, as have been the stimulating researches on the mechanism of immune reactions

The Congress closed formally with a business session on September 9, at which committee reports were accepted, including that of the nomenclature committee This group straightened out some of the conflicts which have so plagued bacteriologists The Fourth International Congress for Microbiology was scheduled for Copenhagen in 1942 The president of the International Association of Microbiologists which conducts the congresses is to be elected within the next few months by the principal microbiological organization of Denmark

GEORGE PACKER BERRY, M D,
Professor of Bacteriology
UNIVERSITY OF ROCHESTER

THE MEETING OF THE AMERICAN CHEMICAL SOCIETY IN BOSTON

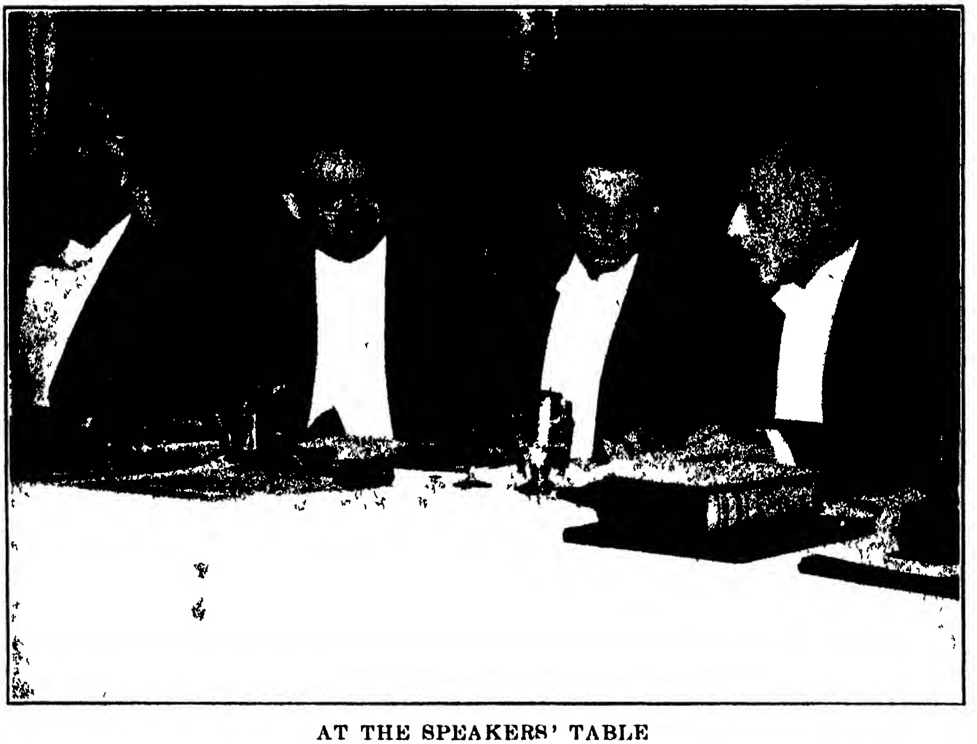
THE centenary celebration of Charles Goodyear's discovery of the vulcanization of rubber was a feature of the ninety-eighth meeting of the American Chemical Society, which took place in Boston from September 11 to 15 The program of the general meeting of the society was devoted to Goodyear's discovery and its applications, rubber was also the subject for discussion at the subscription dinner, which was attended by 965 members and which was addressed by Drs P W Litchfield, Karl T Compton and J B Conant The centenary was also marked by an exhibit, in which the rubber industry participated, arranged by the division of

DISTINGUISHED CHEMISTS AT DIRECTORS' DINNER

DR CHARLES A KRAUS, PRESIDENT OF THE SOCIETY AND DIRECTOR OF CHEMICAL RESEARCH, BROWN UNIVERSITY, DR SAMUEL COLVILLE LIND, PRESIDENT ELECT OF THE SOCIETY AND DEAN OF THE INSTITUTE OF TECHNOLOGY, UNIVERSITY OF MINNESOTA, AND DR HOBART H WILLARD, PROFESSOR OF CHEMISTRY AT THE UNIVERSITY OF MICHIGAN

rubber chemistry, the announcement of the Charles Goodyear Lectureship to stimulate rubber research and to recognize outstanding contributions in the field, and the action of the Board of Directors to sponsor the nomination of Goodyear for election to the Hall of Fame The twenty-five papers presented



AT THE SPEAKERS' TABLE

P W LITCHFIELD, PRESIDENT OF THE GOODYEAR TIRE AND RUBBER COMPANY, J M BIERER, TOASTMASTER AND CHAIRMAN OF THE DINNER, DR JAMES B CONANT, PRESIDENT OF HARVARD UNIVERSITY, AND DR KARL T COMPTON, PRESIDENT OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

in the division of rubber chemistry were of interest in view of the centenary, sixteen were included in a symposium on the vulcanization of rubber, during which the use of agents other than sulfur in vulcanizing were particularly examined. The possibility of producing "artificial" rubber economically was also discussed at the division meeting; it was suggested that butanes and pentanes obtained from petroleum may be converted into butadiene and isoprene, the basis of "artificial" rubber.

Outside the field of rubber research, one of the most widely discussed papers was that by Dr. George Calingaert, who announced the discovery of a new type of chemical reaction. By adding certain specified catalyzing agents, he found it possible to weaken the chemical bonds in the molecules of certain chemical compounds, and thus to cause reactions between compounds which had hitherto been considered inert toward each other. Parts of molecules thus become redistributed in harmony with the laws of probability rather than in accordance with chemical laws. Such "redistribution reactions," as they have been named, do not involve changes in heat, appearance or physical state, and only when the substances of a mixture are separated is it possible to determine whether new compounds have been formed. It was suggested that this newly discovered type of chemical reaction may be responsible for such hitherto unexplained processes as the aging of liquors. A wide range of applications in industry is foreseen; the elimination of intermediate steps in certain processes is made possible, and waste is avoided because the reaction involves every part of the compounds present.

The 568 papers presented at the meeting were divided among the eighteen technical divisions of the society. Symposia, often including representatives from more than one division, were presented on a large variety of subjects, both theoretical and practical. One symposium was devoted to training and opportunities for women in chemistry.

The symposium on industrial wastes discussed legislation proposed to end pollution caused by industrial plants; the creation of a federal board to study the question and draw up uniform legislation was urged by speakers. The problems in individual industries were considered, and it was emphasized that waste treatment should be considered in planning new industrial plants.

The papers presented at the symposium on vitamins and nutrition included announcements of several discoveries. A

DRS. WHITMORE AND EGLOFF

DR. FRANK C. WHITMORE, PAST PRESIDENT OF THE AMERICAN CHEMICAL SOCIETY AND DEAN OF THE SCHOOL OF CHEMISTRY AND PHYSICS, PENNSYLVANIA STATE COLLEGE, AND DR. GUSTAV EGLOFF, DIRECTOR OF RESEARCH, UNIVERSAL OIL PRODUCTS COMPANY.

method of separating vitamins A_1 and A_2 by the use of hydrochloric acid was reported. Xanthophyll, the chemical causing the color in "yellow-legged" chickens, was found to be a necessary ingredient in chicken feed, and was therefore stated to be a vitamin. The discovery of a new vitamin, B_x, preventing the graying of hair, was announced.

The numerous other papers presented at the meeting included announcements of such widely varying discoveries as a process of canning blue crab meat without discoloration, the successful appli-

cation of spectroscopy in determining minute quantities of metals in animal tissues, and a powerful but non-deleterious new germicide prepared from whale oil

Registration at the meeting totalled 3,924; forty-seven states and twenty foreign countries were represented Excursions were made to nearby points of interest, and programs were arranged by the faculties of neighboring educational institutions Reports were submitted by committees appointed to prepare a pamphlet guiding prospective chemistry students, to accredit institutions teaching chemistry and to study problems of small local sections Formal sessions of the society were concluded on September 15; it is planned to hold the next meeting of the society at Cincinnati from April 8 to 12, 1940

B. I G

CASUALTIES IN SCIENCE

It is natural to think first of the casualties of war as consisting of the men killed and injured As tragic as such losses are, their consequences are probably no more serious for the future of humanity and civilization than are the destructive effects of war on the finer things of the mind Already science is suffering serious wounds

Last year in September a congress on malaria in Holland was disrupted by the international tension over Czecho-Slovakia The meeting of the British Association for the Advancement of Science, which was to be held in Dundee, Scotland, during the first week of last September, was interrupted after it started, one of the results being that Dr Isaiah Bowman was unable to deliver his address as the first exchange lecturer under the arrangement between the British Association and the American Association The programs of the recent scientific congresses reported in this issue of The Scientific Monthly were impaired by the fear of war that deterred many foreign scientists from attending them Future scheduled scientific congresses will be postponed or abandoned if the war continues

Scientific publications likewise are already suffering. It has been announced that *Science Progress*, now in its thirty-fourth volume, will be discontinued, at least for the duration of the war In fact, *Nature* has stated that British scientists will resolutely devote their energies to winning the struggle In neutral Holland Dr Frans Verdoorn is finding it difficult, if not impossible, to continue the publication of the distinguished *Chronica Botanica* International weather services, on which safe transoceanic airplane flights depend, are seriously impaired

Scientific expeditions will generally be abandoned or suspended Already it has been announced that the expedition to the South-Central Pacific Islands will not be undertaken, and one of the U S Government vessels that was to accompany Admiral Byrd's projected explorations in Antarctica has been withdrawn It would be worth while for some one to keep a record of these casualties of science

Naturally the countries at war are suffering the most serious consequences to their cultural life The attendance at all their universities will be reduced, and inevitably the historic atmosphere of these famous institutions will be poisoned by the war It is reported that twenty-two German and Austrian universities will be closed, leaving only those at Berlin, Munich, Jena and Vienna in operation No glories of war can illuminate the darkness produced by the closing of these many famous centers of culture.

F. R M.

LUNAR ECLIPSE ON OCTOBER 27–28

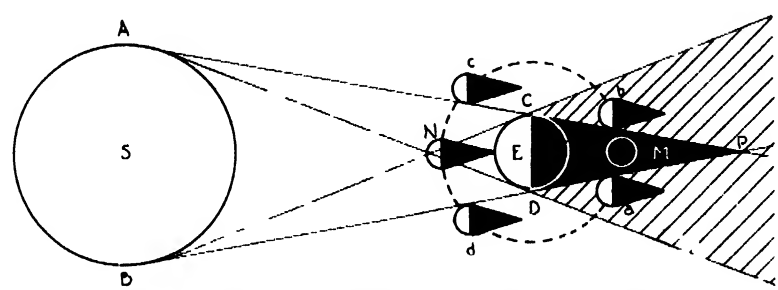
On October 27, at six minutes before midnight, Eastern Standard Time, the moon will begin to pass into the earth's shadow. At 1·36 A.M. the eclipse will be at its maximum, when 99.2 per cent of its disk will be darkened. The eclipse lacks a little of being total because the moon does not pass centrally through the earth's shadow but across its southern border, as is shown in the diagram. At 3.18 A.M. the moon will emerge completely from partial eclipse.

Since the shadow of the earth is opposite to the sun and the eclipse occurs during the midnight hours, the moon will be near the meridian and most favorably situated for observation. There is a partial shadow around the region from which the sun's light is entirely cut off, also shown in the diagram. Consequently, the moon will be gradually darkened for an hour before the moon begins to enter the complete shadow.

It is slightly erroneous to speak of the shadow of the earth as being complete, because the thin layer of the earth's atmosphere acts somewhat like a converging lens and bends some of the rays from the sun into the shadow cone. These rays are mostly the orange and red because the atmosphere absorbs the blue end of the spectrum and partially transmits the red, a fact that is illustrated by the deepening color of the sun as it sets. The moon is therefore dimly visible when it is in eclipse, but copper-colored instead of yellowish white. The gradual change in color can be noticed for a considerable time before any part of the moon is in the complete shadow.

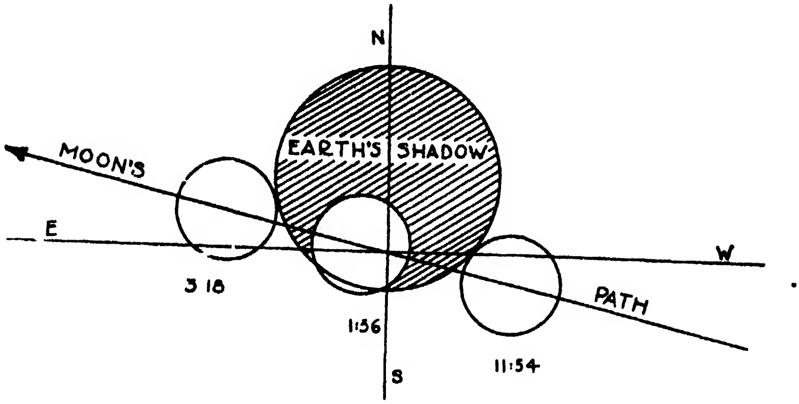
When the moon is near its position of greatest eclipse the part remaining lighted will appear like a shining support for a dim copper-colored balloon above it. On this uneclipsed portion there are the Doerful mountains, whose peaks reach 26,000 feet above their bases. In spite of their great altitude they are not separately visible without optical aid.

In pre-scientific days eclipses of the moon were regarded with superstitious awe, for apparently it was covered by some mysterious darkness coming out of the unknown. Yet the ancient Greeks understood fully the general relations of the sun and the moon and knew that lunar eclipses are due to the earth's shadow. At an even earlier date the Chaldeans had discovered from many centuries of records of the occurrences of eclipses of the sun and the moon that they recur under approximately similar circumstances in periods of 18 years and 11.32 days. With present knowledge of the motion of the moon the times at which eclipses will occur can be predicted almost to the second as long in advance as may be desired.



RELATIONS OF SUN, EARTH AND MOON FOR VARIOUS POSITIONS OF MOON

LETTER S REPRESENTS THE SUN, E REPRESENTS THE EARTH AND a, M, b, c, N AND d REPRESENT THE MOON AT VARIOUS POSITIONS, OF COURSE NOT IN TRUE SCALE. THE MOON AT a IS IN THE PARTIAL SHADOW OF THE EARTH, AT M IT IS TOTALLY ECLIPSED AND AT N IT ECLIPSES A SMALL SPOT ON THE EARTH.



PATH OF THE MOON THROUGH THE EARTH'S SHADOW ON OCTOBER 27–28
ON OCTOBER 27, 11 54 P M, THE MOON IS IN THE EARTH'S PARTIAL SHADOW AND JUST ENTERING THE COMPLETE SHADOW AT 1·36 A M THE ECLIPSE IS AT ITS MAXIMUM, AFTER WHICH THE MOON PASSES OUT OF THE SHADOW, AND FINALLY LEAVES IT AT 3 18 A M

Although eclipses of the moon are not of as great scientific importance as eclipses of the sun, yet they offer opportunities for several interesting investigations The most important of the problems which are investigated at times of lunar eclipses is the temperature of the moon's surface at its midday When the moon is eclipsed its day side is obviously toward the earth, for the sun and the moon, as seen from the earth, are in opposite directions Therefore, just before an eclipse the visible portion of the moon has been exposed to the sun's rays for several terrestrial days, because the period of the moon's rotation is about four weeks Since the moon has no atmosphere, its surface becomes highly heated during its long day The question is to what temperature it is raised

When the moon is eclipsed its day has been rapidly changed into night Before eclipse the energy received from it by the earth is partly reflected solar energy and partly radiated energy It is essentially impossible to separate the two But during eclipse all the energy received from the moon by the earth is radiated heat From measurements of this heat it has been found that the temperature of the moon's surface at its noon is about 250° F During its long night of fourteen terrestrial days its temperature descends correspondingly low, possibly to two hundred degrees below zero At least, during the relatively brief interval of a lunar eclipse it falls below the freezing point of water The extreme range in temperatures on the moon would probably preclude the existence of life on its surface, even if there were no other very serious adverse conditions

F R M

THE SCIENTIFIC MONTHLY

DECEMBER, 1939

WHAT CHEMISTRY IS DOING TO US AND FOR US

By Dr. ROBERT E. BURK

PROFESSOR OF CHEMISTRY, GRADUATE SCHOOL, WESTERN RESERVE UNIVERSITY

WHILE I shall not pretend to rate chemical feats in their order of importance, we may start with the fixation of nitrogen This is done mainly by converting nitrogen from the air and hydrogen from water into ammonia, by the Haber process This may be used as such or converted to various compounds Nitrogen in these forms is assimilable by plants and can be made in unlimited quantities Other elements not universally available are required by plants in much smaller quantities. The ammonia process is the chemist's refutation of the Malthusian principle that populations tend to outrun their ability to maintain themselves Since no one can set a limit on the amount of ammonia chemists can make (the world is now over-supplied), no one is justified in accepting the Malthusian principle.

The opening of the World War in 1914 coincided with the large-scale manufacture of ammonia under the guidance of Professor Haber. This was no accident, since nitric acid, necessary for explosives, is made from ammonia, and without this process Germany would have been obliged to get nitrates from Chile through the British blockade

The synthetic ammonia industry started in this country about 1922, with a production of about 5,000 tons per year. This had about doubled by 1925, had increased to 130,000 tons by 1930 and at the present time amounts to nearly 200,000 tons a year This is a typical growth curve for an industrial chemical The leading manufacturer is said to have spent $27,000,000 on synthetic ammonia over a period of ten years before it began to break even

The World War showed the value of mechanized fighting equipment, particularly airplanes and tanks Germany had no appreciable internal supply of petroleum, but they did have coal The Germans, consequently, carried out large-scale research work on making gasoline and lubricants from coal They have succeeded in developing two successful processes, the Bergius and the Fischer-Tropsch Germany is making more than 2,500,000 tons, or more than eight hundred million gallons, of gasoline a year by these processes If this state of preparedness again coincides approximately with a war, don't shoot the chemist—remember he has no strong voice in politics in Germany or elsewhere.

There has been much concern over the dire consequences of the exhaustion of our own petroleum resources, and the date has been set for the funeral several times. However, we can convert coal to petroleum by the German processes for a sum not much greater than the present tax on gasoline, so when the day arrives, all

we shall have to do is to induce our government to economize, take the tax off gasoline and we shall never know the difference Whether that will be easy or not I do not know. There is enough known coal in the United States to last us more than 3,000 years at the present rate of consumption, and when it is all gone, we can find the rest of it or raise plants for conversion to alcohol or burn wood directly or use shale oil or use various other schemes All the petroleum which has ever been used is approximately equal to one cubic mile I personally have seen mountains of oil shale in Colorado which must represent many cubic miles, but it will probably be used only after most of the coal is gone, if at all In any case, if our chemists have an opportunity to function we shall not lack energy to run our cars in 1950, the year 2,000 or the year 3,000

While speaking of gasoline, I should like to say something on cracking and anti-knocks The work of William Burton and others on oil cracking and of the General Motors research staff and others on anti-knocks has resulted in an average increase of some 10 per cent in the power derived from a gallon of motor fuel at the present time and has about doubled the yield of gasoline from crude oil. This amounts to a gain of roughly a billion horse-power in this country alone Now it seems that there is a remarkable river named the Tennessee which runs through Tennessee but drains all forty-eight states, a power which is derived from a body known as the Tennessee Valley Authority Without attempting to weigh the price against the glory of this authority, I have added up the approximate horse-power in the contemplated electric installations of all the TVA dams, *i.e.*, Wilson Dam, Norris Dam, Wheeler Dam, Pickwick Landing Dam, Guntersville Dam and Chickamauga Dam, and the sum of all these monuments is about 715,400 horse-power. This is less than one tenth of one per cent of the horse-power gained from the anti-knock and cracking research Moreover, I have never heard a single politician eulogize William Burton or the General Motors Corporation for their work in conservation In any case, we shall plainly be dammed in a big way if politicians try to equal the power conservation feats of the chemist by building the thousand odd TVA's which would be necessary

Chemical industry, until recently, was almost synonymous with the dyestuffs industry This child of Sir William Perkin is so much in evidence that little need be said about it Purple used to be referred to as "royal" purple because only the upper class could afford it and it was prized accordingly To-day all colors are so cheap that choice of color may surely be esthetic and not influenced by the prestige of high price. The American dye industry started only when the German supply was cut off during the World War In 1925, we produced about 12,000,000 pounds of dyes per year, which rose to 32,000,000 pounds in 1930, and to 100,000,000 pounds in 1935 This typifies the vigor of a chemical industry The leading manufacturer (du Pont) is said to have spent $45,000,000 on this industry over a period of 18 years before it began to make a profit. I do not know whether this is a reflection of bad judgment or of courage and wisdom, but I have given it credit for the latter.

Metals and metal products in 1935 sold for about $13,500,000,000 To a chemist, metals are chemicals as definitely as sulfuric acid is Iron, copper, aluminum, chromium, nickel, silver, magnesium, gold, all form the basis of industries, but they likewise find places in the periodic table of the chemist It would be tiresome to dwell on the details of the contributions of chemistry in developing stainless steel, high-strength steels, steels resistant to high or low temperatures, or to discuss in detail nickel, chromium,

zinc, cadmium and silver plating, commercial magnesium and aluminum, etc. But it may be permissible to point out that a new, though a very small, baby of the metals field, beryllium, is being reared in Cleveland, and from it can be made such interesting products as tools which do not give rise to sparks and springs which are resistant to fatigue It is lighter than aluminum or magnesium. I might apologize for even mentioning gold as an important metal, but it will be remembered to have once attained that stature, and much public money has been spent for its purchase even in recent years

The present era has been referred to as the plastic age I don't know at the moment whether this is meant to refer to our susceptibility to propaganda or to the fact that the use of plastics or resins is increasing so rapidly In any case the latter trend is shown in Fig 1 [1] The figures represent millions of pounds and do not include allied products such as asphalt, synthetic fibers and rubber. The popularity of resins is, I believe, due essentially to the fact that they provide a wider range of properties in materials than we have ever had before, and moreover their quality can be controlled With all this, prices fall as production increases

Synthetic resins have been used in some rather spectacular ways I might mention lenses for spectacles, clearer and cheaper than ever and unbreakable We now have plastic lenses fitted directly to the eyeball Some resins have optical properties formerly expensive to obtain, *e g*, ultra-violet transmission and ability to conduct light around corners (Lucite). I have a transparent oil can, an invention which may spare an oath or two. Certain vinyl resins have the property of being nearly completely tasteless and odorless This makes them specially suited for dentures, toothbrush handles, etc. Synthetic resins provide adhesives which can be heated with water without soaking off. Some of them are the most satisfactory insulating material yet found

Moreover, one should not fall into the error of regarding a resin of a given chemical type or trade name as a more or less constant thing, such as some particular species of wood Most of the resins are backed by research staffs which are constantly improving them I imagine many would think the idea fantastic that metals will be replaced by resins in many of their applications But resins are light, readily fabricated in mass quantities, do not corrode, are often

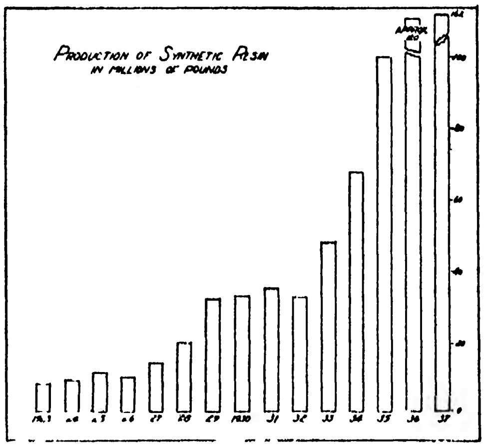


Fig 1

adequately strong for the purpose and have other interesting properties Actually, there are already many companies engaged in fabricating products from resins which were formerly made from metals

Synthetic rubber is a close relative of synthetic resins. Four different varieties of synthetic rubber or near rubbers are produced in this country on a considerable scale, a fifth is produced in Germany and a sixth in Russia It is interesting to note that only one of the six was developed in the laboratories of a rubber company, just as one of the most important recent developments in producing oil came from a chemical company, and one

[1] From the magazines *Chemical Industries* and *Industrial and Engineering Chemistry*.

of the most interesting chemical developments (synthetic glycerin) came from an oil company

Synthetic textiles are related to, and in some instances are chemically identical with, synthetic resins and plastics They are simply made in filamentary form That rayon manufacture is a large industry is scarcely news The present production is at the rate of about 300,000,000 pounds per year, which is about three fourths of our wool production, though still small in comparison with cotton production It may not be generally known, however, that linen, cotton and other goods can all be simulated and probably improved in rayon

Another interesting newcomer in the textile field is glass cloth, which is actually 100 per cent glass The factory in which this material is made was converted from a bottle factory The material is of course absolutely fireproof Its main use so far has been in electrical insulation Electric motors insulated with glass cloth can be made with twice the power for a given size because they can be run hotter without damage to the insulation The material is also useful wherever cloth is desired which is resistant to light, heat, chemicals, etc It is not anticipated that suits and dresses will be made of glass

The glass industry has been progressive in other directions. Safety glass, in which a layer of plastic material is sandwiched in between two layers of glass, has saved many lives It has been improved until it is unaffected by light A new variety yields so much under impact that the blow experienced by a passenger thrown against it in an accident is definitely softened

We have glass which is resistant to mechanical shock, glass which is resistant to temperature, and recently glass which you can not see No doubt you have seen with approval some buildings utilizing translucent, insulating glass brick. Insulation in housing is a development which was surprisingly slow in view of the established principles of insulation, yet one which no doubt is destined to make an important contribution to comfort and to the conservation of our fuel resources

The trouble with building is that it is done largely by relatively small organizations without important research facilities Consequently, houses improve slowly in comparison with, say, automobiles

Air conditioning is a substantial and a growing industry which is partly, though not entirely, chemical It doesn't mean much as yet in the North One must go South in the summer time to appreciate it It is, however, a development which seems destined to make important contributions to health in cities Closely connected with this topic is the art of refrigeration. Artificial ice was an important development for health and comfort, but a private ice plant in your home is a better one in the eyes of some millions of users Imagine a hospital without refrigeration! More recently we have the preservation of foods by quick freezing, a process which most observers would agree preserves food with a much closer approximation to the original taste than canning

One could scarcely review the practical accomplishments of chemistry without mentioning photography and its vigorous child, the motion picture industry. Active research has made colored photography practical, and active research is being conducted to improve it We have a professor who finds this scientific creation a relief even from literature The leading photographic company in this country employs more than four hundred research scientists

Medicines, antiseptics, hypnotics, vitamins and hormones are amongst the brilliant triumphs of chemistry as a partner in the field of medicine, but I shall not dwell on them at present.

While I have hit only the high spots in chemistry's contributions to modern society, it might get tiresome to discuss finer details. As to the magnitude of applied chemistry, if one defines chemical industries as those in which the products or processes can be described in definite chemical terms, he would be obliged to include chemicals proper, petroleum, rubber, glass and ceramics, metals and textiles, but not the fabrication of metals and textile products. The products in this non-inclusive chemical group were sold in 1935 for approximately thirteen billion dollars. This is an impressive fraction of our national income, even though many partly chemical industries have been omitted from the list.

What can be said on the side of chemistry which some consider to be detrimental? Opinions, of course, vary as to the value of different inventions. For example, I don't like dial telephones or gelatin in ice cream. Others dislike radios; still others automobiles.

The alleged major crime of science has received the high-sounding name of technological unemployment. The idea may be illustrated by the cigarette industry, where high-speed machines have been introduced which produce prodigious quantities of cigarettes per man employed and which industry has experienced a steady decrease in employment. Aside from the fact that few would wish to condemn men to a life of wrapping cigarettes by hand, this example, however, is a most unfair representation of the situation. In this industry, the demand is rather flexible, and the public would not applaud strenuous efforts to expand it. The rayon industry or the automobile industry would make a very different impression. Fig 2 (from *Chemical and Metallurgical Engineering*) shows the trend of production and prices in the rayon industry and is typical of a scientific industry where demand increases as prices decline and quality improves, as the result of intensive research. A similar diagram showing the still more striking increase in the production of synthetic resins has already been presented. Whether more or fewer men will be employed in course of time in such an industry as a result can not in general be predicted.

According to the October, 1938, number of *The Chemist*, a publication of the American Institute of Chemists, the horse-and-buggy business gave jobs to around one million persons in 1900. In 1937, the automobile industry furnished

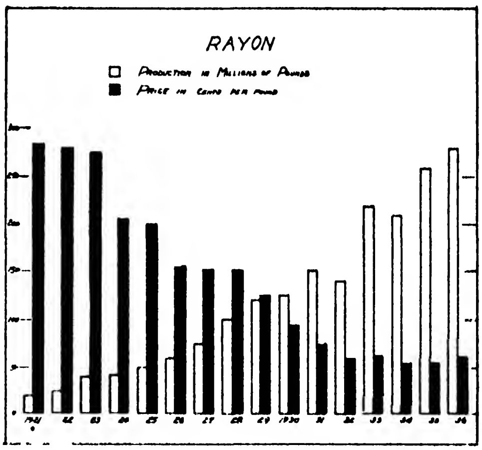


FIG 2

employment to over six million persons in making, selling and servicing cars. Moreover, a million persons are employed directly in the petroleum industry. In addition, many thousands of man-years are expended in what to some people is the pleasant pastime of riding around in automobiles.

Any balanced discussion of alleged technological unemployment likewise must consider new industries created by science, of which there are many. Of these the recreation industries, which already involve more than 8 per cent of our national income and which lap over with the field of education, should be pondered by those who are inclined to

worry over alleged unemployment resulting from applications of science

I visited one of the large continuous steel strip mills which stand out as a high achievement in mechanized processing It would be easy for a breast-beating agitator to infuriate a mob over them. A huge output of finished steel comes out of these gigantic machines with scarcely any one in sight Since here is an industry where the demand is flexible, I inquired as to the overall effect of this equipment upon employment in the steel industry I learned that employment in the steel industry as a whole increased 23 per cent. from 1926 to 1937, whereas employment in four leading steel com-

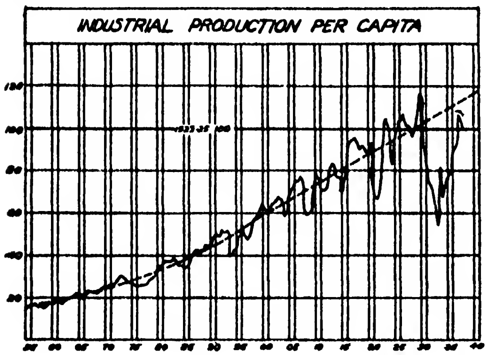


FIG 3

panies, operating continuous mills for all or part of the period, increased 28 per cent. in the same period This takes no account of the huge capital expenditures involved in the mills themselves, representing more employment

The true situation with regard to technological unemployment appears to be that as a national factor it doesn't exist. As Dr K T Compton, president of the Massachusetts Institute of Technology, and others have recently pointed out, "statistics show no decrease in the fraction of our population gainfully employed during the last few generations in which machine production has become important " The magnitude of the increase of manufacturing efficiency during this same period is very large, as shown in Fig 3, from an issue of the *Business Bulletin* of the Cleveland Trust Company

One factor seldom discussed in connection with alleged technological unemployment is the increasing number of women in industry Leaving out the field of domestic service, the number of women now employed is at least equal to the total persons unemployed If women are better fitted to do some of the work men used to do, they will probably do it in the end, and the less competent men, I suppose, may have to do the dishes and take care of the babies But in any case, I do not see the justice of blaming the chemist for that situation.

The harshest thing which can be said of science with respect to technological unemployment is that sometimes men are obliged to shift jobs We wish, however, to do something about some ten million people who may desire to work. The scientist interested in the economic effects of his work must be impressed by the effect of taxation of industry on employment and as a repressing factor in the application of science This is relevant to the present discussion, because it is an insidious force which tends to stunt the normal growth of scientific industry. The factor is particularly striking in the petroleum industry Here the application of scientific methods has reduced the average retail price of gasoline from more than 29 cents in 1920 to less than 14 cents in 1937, or about one half, the figures being without the large retail tax This technical triumph has been in spite of rising labor costs and rising indirect taxes, and the quality has improved. But much of the gain has been offset by direct retail taxes, which in some states amount to nearly twice the wholesale price of the commodity in spite of the fact that gasoline is now a necessity for most people. This industry pays total taxes amounting to much more than the total net income

(after taxes) of the industry. While tax money is also spent, it must be particularly emphasized that it is not spent in the discriminating way which encourages the growth of those particular industries which should grow, namely, those capable of expansion through flexible demand, lower prices, improved quality and new uses One does not have to be expert in the field of economics to perceive that such predatory government policies as are exhibited in the petroleum industry produce unemployment, for which the scientist is blamed, instead of the politician

A third alleged crime of chemistry and science in general is the destruction of capital through obsolescence I can at last agree that though more wealth is created than is destroyed, this is a well-taken criticism. If the executives of a company insist upon ignoring scientific research and the improvements in their products and operations which scientific research makes possible, and their stockholders allow them to take this attitude, then there is little doubt but that their business will not prosper as it otherwise would. But the privileges of thus dying is not wholly a bad thing It would require a high order of oratory to provide an equal degree of persuasion to business men that they should engage in large-scale research

Ten years ago, *Barron's Weekly* conducted a contest on the problem, "How to Invest $100,000 for a Widow" The man who gave the best answer as judged by the ten-year record was recently asked to give a new answer for the next ten years He then advised that she invest $70,000 in a well-diversified list of common stocks chosen almost entirely from those companies which are known to be in a good position to benefit by scientific research and development

But that is only an opinion Some facts may be more forceful in illustrating the conspicuous success of research in industry For this purpose, I have examined the financial records of certain companies, of which some are conspicuous for aggressive research, others of which are not The companies are all representative and prominent in their respective fields It does not represent an exhaustive study of all companies in the country, which, so far as I know, has never been made It is difficult, likewise, to find companies which pursue opposite research policies in the same industry. Finally, I do not pretend that the quality and quantity of research is the sole factor in the financial records of these companies The figures are from "Standard Corporation Records" I have examined the net earnings of the Dow Chemical Company over the past five years, which did not come even near to sustaining a loss in the great depression It is spending about $1,400,000 a year on research, with net sales of about $25,000,000 a year

The E I du Pont de Nemours and Company has had a continuous record of net income since 1926 It is noteworthy that their 1936 and 1937 earnings exceeded their 1929 earnings Their research expenditures are at the rate of more than $7,000,000 a year, and their net sales about $286,000,000 I think it is safe to say this company spends more money on chemical research than all the universities in the country combined

The Union Carbide and Carbon Corporation has had a similar record. Its 1937 earnings were at an all-time high This company has never incurred a loss or passed a dividend. Their research expenditures are not available, but are high

Next, let us look at a large railroad company Railroad earnings may be complicated by having to deal with strong labor unions and government control Nevertheless, though they are themselves merely exploiting an invention, they are not known to be aggressive in

research. The New York Central Railroad had a deficit of about $18,000,000 in 1932 and only a meager return in 1937 in comparison with 1929.

The Pittsburgh Coal Company, one of the largest coal companies in the country, has had a deficit every year but one since 1925. If research is carried out by them on a large scale, I have never heard of it and it is not mentioned in "Standard Corporation Records," nor in the National Research Council Records

The Long-Bell Lumber Company, one of the largest in its field, has had an almost continuous record of heavy losses since 1925 and has had to go through reorganization Lest it be concluded that the record of this company is the inevitable result of the decline in building, let us examine the record of the net earnings of the Johns Manville Company, also dependent upon the building industry, but well known for its aggressive research policy It has had no deficit since 1926 and in 1937 it is to be noted that its net earnings approached the all-time high

The very least one can say is that all this evidence is in favor of the idea that aggressive research work in industry pays very well and preserves the capital of those who practice it

Another danger of applied science with which I might agree is that there is a tendency to try to get along with too little knowledge We may be in a critical period now in this regard Thus I take vitamins every day and am under the impression that my health is improved thereby But I should feel more comfortable about this practice if knowledge on the subject were more extensive The generalized point is that we are heavily involved with science and it seems wholly illogical and impractical to try to turn the clock back Yet our knowledge is so scant that we may pinch our fingers here and there trying to make the machine work, unless we have more definite information with which to run it.

It would reflect no credit on chemistry if I were to attempt to disparage other branches of learning, which is far from my intentions Nevertheless, the impression is growing that current leadership in the fields of business, politics, labor unions or education, if you please, can not be effective without large masses of incontrovertible facts, without sound scientific guidance

Though it has been said that "pearls of great price can not be had for the asking," the material pearls which science has produced have been sold very cheaply In the past, inventors' receipts from important inventions are commonly less than a broker's commission for handling articles of commerce But the most valuable pearl which science has produced is dangling in front of us absolutely free, yet largely ignored This is the demonstrated value of facts as against opinions This is the key to the growth of science Why isn't this principle more contagious? Why can't some of the billions which the public seem willing to squander on a gleam in some politician's eye be devoted to the acquisition of such a body of tangible facts as will guide us properly?

The high valuation which we should place upon facts brings a defender of chemistry to questions of the influence of science on the moral and spiritual well-being of man Millikan, Compton and others have written and spoken on the lack of conflict between science and religion, and a technical discussion of that subject will be avoided However, some writers, beginning at least with Robert Southey, have bemoaned the rise of the scientific age as a destructive force in the spiritual progress of man This force is represented as attaining a hurricane stage in the mass production industries of the present day But while some authors may not like to run lathes, it is my personal observation that lathe hands are not a particularly unhappy lot Labor

generally is probably at least as well off as in the days when they endured the burdens of the Middle Ages. I should go much further than that and represent science as an exceedingly powerful spiritual and moral force If a man doesn't learn moral lessons from the observation of the certainty of operation of natural laws, he seems to me to be morally hopeless The qualities which we commonly associate with high character are, according to my observations, especially marked in persons who have a deep appreciation of facts Which is cause and which effect it is difficult to say, but in any case, the two are compatible

I believe Abraham Lincoln emphasized strongly the importance of respect for law But this advice can be followed only if the laws are respectable Even the time-honored and respectable man-made laws are broken and it takes a lot of policemen to enforce such observance as we have Now it is an indisputable fact that people do not try to break natural laws if they have any comprehension of what these laws are Surely the lunatic who tries to fly with an umbrella will not be cited against me at this point Is it too much to hope that legislators and the public at large will, some day, grasp the implications of this comparison, that they will think again before they say "there ought to be a law"?

The spiritual stimulation of what are sometimes referred to as "cold facts" may not be so obvious as their moral effect It is well known that producing scientists are inclined to work hours which would cause a popular uproar (to say nothing of violating a federal law) if employers imposed them on their employees Is this because scientists are simply queer animals? Possibly they are a little queer, at least the rest of them may be, but I imagine the effect is due to a degree of interest which is difficult for those not similarly stimulated to understand—an interest derivable from the "cold facts" of science, though, of course, not alone from science It is difficult to purchase equally satisfactory amusement, as Lord Cavendish, the Duc de Broglie, the Prince of Monaco and other men possessing both wealth and intelligence have found out

Perhaps I can illustrate the stimulating effect of cold facts by means of an example The course of political and economic events over, say, the next decade will assuredly follow some pattern or other, and most of us wonder what it will be For the sake of illustration, let us suppose that an exponent of some branch of political science could predict such a course of events with certainty, and that there was general confidence that he could do so (I must apologize for the fantastic character of this illustration) But in that event, I think all would agree that a lecture on that subject would arouse the most intense public interest The cold facts alone would have that result—no high-powered oratory would be required

Unfortunately, I am not sufficiently skilled in the proper field of political science for such a valuable prophecy, but in the field of chemistry sufficient information has emerged from research laboratories to justify some predictions

I pointed out that hundreds of millions of horse-power have been created by the efforts of chemists in the field of motor fuel There is a steady advance in this field which must continue for some time. Diesel engines have been held back by such factors as higher first cost This is due at least in part to the circumstance that they have not been produced in large numbers In other words, the spark ignition engine got there first The problem of mixing the fuel and air is a problem in the Diesel engine which, however, does not seem to be inherently insoluble. Diesels have been increasing in number, and I should hesitate to predict the end.

Medical research is bound to make fur-

ther strides. Industrial medical research has grown rapidly in such laboratories as Abbott, Lilly, Squibb, Parke-Davis, etc. Since the public wish to be cured and are quite willing to pay for being cured, I should not be surprised to see a very large growth of medical knowledge emanating from such laboratories. Less research is carried out on making the human machine run properly than on making automobiles run properly, yet surely automobiles are less important than human beings The obvious difference is that research on automobiles and their fuels and lubricants is commercialized—I should say decently so—while medical research has been to a considerable degree restricted by what their authorities consider to be ethical taboos against commercialization I hope it will be possible for academic medical research to be so related to the industrial medical research that it will not be eclipsed and can be adequately financed As a subject for a future Nobel award in biochemistry I should like to suggest a pill which would soften the emotion of jealousy

Chemical control of plant growth is one of the most promising research developments of current interest. It has gone far enough to make one sure it is going farther It seems that the extent of growth of plants does not proceed to some inherited limit, as with animals, but is rather related to their food and light supply Moreover, plants in some circumstances may be fed intensively from solutions more conveniently than in soil. This technique is an established commercial success, *e g*, in raising tomatoes Plant hormones with their specific effects upon plant growth add to the fascinating future of this field

Allied chemical industries of future interest will be those based upon agricultural raw materials Illustrative infant industries are the soybean industry, the tung-oil industry and the production of furfural on a large scale from oat hulls. Cellulose, the main constituent of cotton and wood, is the basis of paper, rayon, Cellophane and the cellulose plastics, *e g.*, cellulose nitrates (celluloid), cellulose acetate and other esters, ethyl cellulose and cellulose ethers These industries are still expanding Agriculture, including forestry, it seems, can best continue to supply the raw material for these products Who can deny that if the next billion dollars appropriated for farm relief were spent instead for research on the better utilization of farm raw materials, the result would be a cure instead of relief for the farmers?

Alcohol and sugar are made from wood in Germany, but whether alcohol will eventually be made from molasses, beets, Jerusalem artichokes, sweet potatoes, petroleum, wood or coal in this country has not been made clear.

Protein chemistry is being studied extensively at the present time. Something will come of it, but the work has not settled sufficiently to say just what. The physiological response of protein-like structures and of particular chemical groups in proteins is obviously important

The probabilities for continued lowering of costs and still further increasing variety and quality of textiles and plastics are plain It requires no special psychic power to predict that both industries will continue to grow in importance Synthetic fibers will probably replace natural ones more and more completely for at least four reasons: (*a*) They are more uniform in quality, (*b*) they are continually improved in quality, whereas cotton and flax plants, sheep and silkworms are not quite as progressive, (*c*) synthetic fibers may be built with qualities not possessed by natural fibers; and (*d*) manufacturing costs will probably fall faster than farming costs.

One of the most spectacular of the newer fibers is called nylon. Rayon, being made from cellulose, is not entirely

synthetic, some of it having the same chemical composition as cellulose But this new fiber is made entirely from coal, air and water. It is a polyamide material related therefore to proteins in structure. Its first application is in the lowly toothbrush, since bristles made from it do not soften when wetted This is, of course, more than can be said for hog bristles More interesting to the household budget is that women's hose can be made of the material which are more durable, though more sheer, than present ones. It is likewise expected that this substance will be admirable for tennis racquet strings, since it is strong and elastic yet uninjured by water Finally, the material can be spun finer than silk or rayon. Large-scale production of this substance is expected to start early in 1940

Important research is being carried out on wood itself. The use of synthetic plastics instead of glue has greatly extended the field of plywoods These can be made of uniform and high strength so that objects made from plywood can be engineered as precisely as objects made from a metal Progress is likewise being made in giving to wood other desirable qualities. Thus this substance can either be improved or dissolved and converted into a host of other things

Synthetic chemical products will increase not only from agricultural raw materials but from petroleum and from coal. In fact, there will be probably some lively competition among these raw material sources Thus, glycerin from petroleum has recently been announced in competition with agricultural glycerin

In the field of metals, corrosion seems to be an outstanding trouble at the present time When a trouble is as expensive as corrosion is it can safely be predicted that research work will continue to be concentrated there. One can see no particular reason why quests for new alloys should stop.

Chemists would be dull indeed if they can not further lighten the burdens of the housewife Our rugs are treated with a chemical which makes them permanently immune to moths. Shrinkless blankets have recently been announced. These are cases in point

These predictions are merely a few reasonably safe ones The unpredictable developments are quite likely to be of as great or greater importance Moreover, these predictions are predicted on the preservation of reasonable patent protection on the part of government, without which, in the nearly unanimous opinion of chemists, industrial research can not function In an invention, one creates property which did not exist before How could there be a stronger title to property? It seems incredible that persons who recognize weaker titles (or do they) to such property as real estate should wish to deny patent protection to inventors

Nevertheless, there has been a movement in Washington to diminish the patent rights of inventors Under the McFarlane bill, turned down by the last Congress, a government agent could license your patent to your competitor for a dollar if he so chose. Mr. McFarlane did not return to Congress, but there is a new patent bill and propagandists are at work on the subject of patents, from which I suppose we can conclude that some higher-up has a weird idea and is exerting back-room pressure against patents This patent conspiracy to my mind is the most serious threat to the proper development of science which we have at the present time. If the plot is successful, it would cause a subtle economic disease comparable with keeping industry on a vitamin-free diet. The disease would soon affect academic scientists.

Research policy is interesting in that the magnitude of research expenditures bears no particular relation to research

opportunity. The determining factor seems to be the insight and progressive quality of the management Industries which have but recently emerged from the laboratory are particularly likely to take an aggressive attitude toward research When Horace Greeley told young men to go west the economic reasonableness of his advice was fairly clear To-day the corresponding opportunity lies in science and particularly in chemistry, but the opportunities lie behind such words as catalysis, polymerization, methyl methacrylate, polystyrene, ascorbic acid, etc Twenty years ago a steel manufacturer or fabricator couldn't be

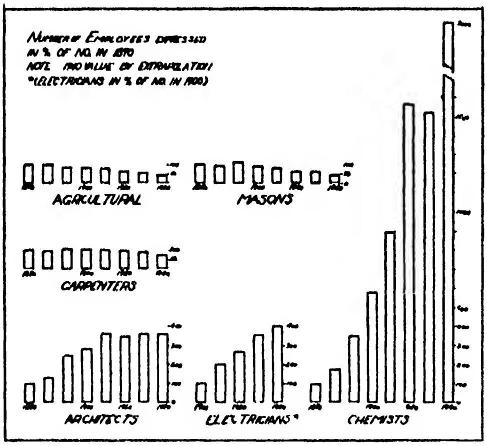


FIG 4

blamed for not foreseeing competition from, say, phenol formaldehyde condensation products Now we may blame him, because it has become clear enough that any industry is likely to be affected by research Companies would now be well advised to build up research as fast as, but no faster than, they can assimilate it

Research itself has become an industry as well as a means to industry Industrial research expenditures are estimated at $250,000,000 in 1937. This is more than 10 per cent of the expenditures on our entire educational system, though a paltry sum for the work at hand Young men faced with the problem of picking a career would be interested in Fig. 4, which shows trends in the relative number of persons employed per million of population in certain representative occupations, including chemists. Research seems to be not only an interesting and prosperous frontier but an inexhaustible one

What effects will industrial research have upon universities? Universities according to tradition are institutions for teaching and learning But already more than 90 per cent of the investigators are in industrial organizations It seems that unless universities can tie in with the industrial work they will exercise the teaching function, but what they should be teaching, in the chemical field at least, will be buried in the files of corporations

The old distinction between pure and applied research can no longer be drawn. The most argumentative would agree that biology is fundamentally dependent upon catalysis, polymerization and oxidation This is because proteins and cellulose are polymers, because enzymes, hormones, vitamins, chlorophyl, the important trace elements and the like are properly classed as catalysts, and because oxidation is the fundamental energy-producing reaction Yet it is my impression that information on these subjects is accumulating faster in industrial laboratories and projects than in non-industrialized medical research institutions This impression is based on some years of experience in coordination information in these fields

A friend of mine who is in a position to know has told me that the volume of new publishable chemistry which is, each month, locked in the files of one of our large chemical companies, alone is equal to all that which comes to light through the *Journal of the American Chemical Society* The chemistry of aliphatic hydrocarbons as we know it to-day has de-

veloped largely in industrial laboratories The petroleum industry has recently developed an easy technique for converting aliphatic hydrocarbons to aromatic ones, a contribution to chemistry of which any university laboratory in the world would be proud. One company has recently published a new system for quantitative analysis by means of x-rays Some of our most useful technique, such as the easily available high vacuum technique, has come from industrial laboratories Automatic instrumentation, developed by industry because it is necessary for precise plant control, is rendering research experiments and observations more accurate than the most zealous human observer could make them

It is idle to suppose in the field of chemistry at least that the able theoretical men stay in universities, while the second-rate ones go into industry Nobel prizes not infrequently go to industrial men these days—Langmuir, Bergius, Davidson come to mind Bright young men who spurn industrial work at the age of 25 are often in it at 35 I could name a long list of top-notch chemists in industrial laboratories Does it not seem unfortunate that such men are not in general so situated that graduate students can have the benefit of their learning and experience?

Corresponding to the growing importance of chemical research and the function of universities in providing properly trained men for the work is also one of growing national importance To do this work well, universities must maintain, or perhaps regain, leadership in chemical research But, alas, this has become a large and expensive job—too large probably to be financed adequately by traditional methods in these days of open season on wealthy men It seems to me that the work of theoretical science in universities is too important to industry to be nourished in the future as in the past merely by the crumbs which fall from the industrial table

We have a new situation in the world of scholarship Never before have hundreds of chemists or any type of scholar been gathered together in one spot engaged in the creation of new knowledge, a situation which exists in many spots to-day Chemical abstracts cover some 200 journal articles and patents a day It requires money and men to keep up with such a parade, to say nothing of leading it It is too much to expect an isolated professor to make much of an impression on such a flood of information

Universities have acquired a new problem in orienting themselves to large-scale organized research They have perhaps a new rival, but also a new and much-needed and much-deserved source of support Scholarship has become tangibly and nearly immediately valuable, and shrewd capital is responding to that realization

Chemists have literally made a silk purse out of a sow's ear, they have literally made a duck sink instead of swim One should not be surprised if they succeed in gaining for able college professors the public respect and economic status which they should have.

RUMFORD AS A SOCIOLOGICAL ENGINEER

By Dr. C. HARRISON DWIGHT

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To the physicist the name "Rumford" suggests, quite rightly, the experiment on the heat produced by friction The Rumford photometer is also usually remembered. Beyond these two contributions to physics, nowadays described in every text-book, the average scientist is frankly ignorant. Except for fragmentary information about certain clever designs in stoves and chimneys, general knowledge of this amazing man becomes rapidly weaker, the final flicker of interest occurring at the mention of Rumford baking powder! Prodded by an occasional student, the physics teacher evolves the information that Sir Benjamin Thompson, later the famous Count of Rumford, was the founder of the Royal Institution of Great Britain, and refers to the Rumford Fund of the American Academy of Arts and Sciences

Count Rumford was not only an experimenter but a scientist in action in sociological problems, applying the tremendous zeal, accuracy of observation and care in conclusions that characterized his entire scientific career to the baffling problems of social maladjustment To the scientific attributes abovementioned must be added, as of vast importance in the "extra-curricular" activities of Rumford, his tact, unfailing courtesy and knowledge of human nature The last characteristic may be illustrated by his own words

> All sums of money or other assistance given to the poor in alms, which do not tend to make them industrious, never can fail to have a contrary tendency, and to operate as an encouragement to idleness and immorality.

Charles Theodore of Bavaria, looking out from his none-too-secure position as Elector upon the world of his time, sensed a situation that boded little good to sovereigns A few miles away the French monarchy was beginning to tremble, and far off across the ocean to the west, on the semi-civilized fringe of a continental wilderness, a few thousand colonials had dared resist the government of their mother country Unrest was in the air—a world epidemic that would break out whenever or wherever the conditions became acute The Elector was full of concern for his three million subjects Not only was his land harassed by internal troubles, but the neighboring states of Prussia, France and Russia were by no means friendly

In September, 1783, Colonel Benjamin Thompson, a fine-looking British officer on extended leave, arrived at Strasburg from England By his geniality and knowledge of practical affairs he won for himself acquaintances among the strangers, among whom was Prince Maximilian of Deux Ponts, nephew of the Elector of Bavaria Continuing his journey into the latter country, Colonel Thompson presented letters of introduction to the Elector, who speedily found from personal contact that he was dealing with the very man who could help him settle the chief problems confronting the country Agreeing to give his aid, Thompson spent the next four years in a careful study of all the economic and social forces at work in his patron's dominions, as well as of the language, mineral resources and industries.

There were in Bavaria at that time two major social problems: the employment of the army in days of peace and the importunities of thousands of beggars.

In order to solve the second problem, the first had to be thoroughly mastered. Realizing that the maintenance of a large standing army was a menace to the people, financially and economically, Thompson instituted drastic reforms Soldiers, though recruited from the soil, refused to return to the simple life when on furlough Colonel Thompson realized that they must be made to see the *desirability* of such a return With the complete acquiescence of the high-ranking officers, he declared that military life would henceforth be shorn of obsolete and useless customs, that each man would be given as much liberty as was consistent with order and subordination, that opportunity would be offered for self-improvement, and that schools would be provided so that not only soldiers, but their children and their neighbors' children, could learn at least the three R's. The government was to supply books, paper, pens and ink Lest the soldiers should have idle time on their hands in spite of the new régime, a "Military Workhouse" was provided for them and their families Raw materials were given to them by the government, the proceeds of the sale of the completed goods being entirely at the disposal of the workers The latter were issued strong canvas working suits The official duties of soldiers in time of peace were largely similar to those of the modern C C C—making and repairing roadways, draining marshes and repairing the banks of rivers The regimental bands played at times of unusually arduous work, while sports and games were encouraged on holidays. Ten months' furloughs were allowed, in rotation, to a large number of soldiers in each garrison, their time being spent in recruiting, in engaging in manufacturing and in agriculture in their home communities To encourage this last activity, Thompson planned a garden in connection with each army post, so that the soldiers could experiment with potatoes, at that time quite a novelty Each man was allotted 365 square feet, which he could cultivate for pleasure and profit The soldiers took pride in their miniature farms and even took seeds and potatoes with them when they went home on furloughs Thus new foodstuffs and better methods of cultivation were introduced to the populace The men were allowed to seek advice and assistance from their officers, who were forbidden to accept any remuneration for their counsel

The reformation of the army meant the first step in Sir Benjamin's plans for the elimination of mendicancy throughout the country This evil was a gigantic and organized system of abuses, tolerated by the government and the people, which made life miserable, and even unsafe, for the majority of citizens The local laws for the support of the poor were utterly inadequate to cope with the situation Beggars and vagabonds, of both sexes and all ages, natives and foreigners, swarmed over the land, lining the roads, robbing houses, stores, workshops and churches What they could not obtain by begging, they sought to acquire by threat Since most of these ruffians were strong and well, and preferred their lazy life to one of industry, they were at once the terror and the scourge of the country Children were kidnapped, maimed and then exposed to the public in order to extort a fixed sum per day Terrible punishment was threatened if the stipend were not obtained Even herdsmen and farmers levied contributions from passers-by, and farm children, too young to work in the fields, were taught to ask for money by the roadside In the cities there were beggars' castes, with rules as to territory, intermarriage and professional privileges of offspring

Thompson's first move was to dispose of four regiments of cavalry in such a

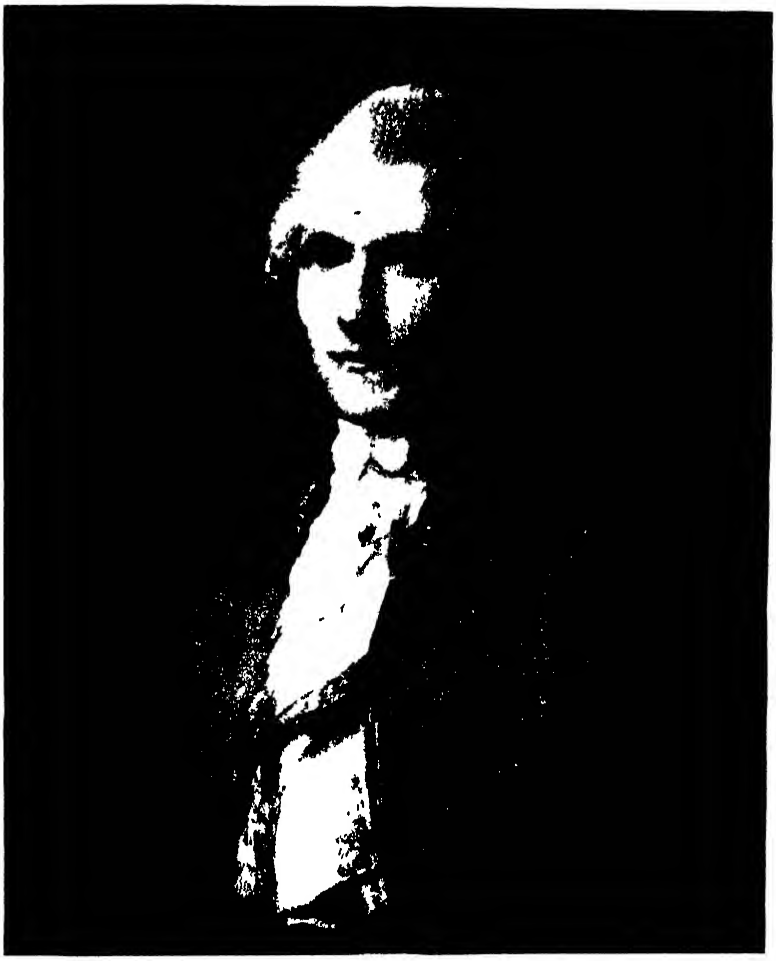
way that every town and village had a patrol party of from three to five mounted soldiers daily coursing from one station to another. The exaction of food, forage and lodging from any peasant's home was not permitted. Officers were detailed to inspect these patrols, and a general officer, having inspected all the cantonments, reported to headquarters at Munich Printed instructions in great detail governed all these matters The patrols had orders to convey government messages, guard the frontiers, prevent smuggling, assist at conflagrations and apprehend all bandits The inhabitants of each district provided for the simple wants of the patrols, and so well and economically was the plan worked out that the entire cost to the country for one year was only a matter of some ten thousand dollars

To take care of the worthy poor and to provide employment for them, especially in the cities, Thompson organized an efficient bureau composed of persons of the highest rank This body, serving without pay, included the respective presidents of the Council of War, the Council of Supreme Regency, the Ecclesiastical Council and the Chamber of Finances, together with a councilor from each of these departments A secretary, a clerk and an accountant were provided at the public expense The city of Munich was divided into sixteen districts, and in each of the latter every dwelling house was numbered, whether it were a palace or a hovel For each district a Committee of Charity was appointed, composed of a priest, a physician, a surgeon, an apothecary and a "respectable citizen" who acted as chairman These persons likewise served without pay, and as a body were affiliated with the general committee The worthy poor were given aid when and in such form as they needed it.

The vagabond class presented a different problem altogether. It was a great feat of "social engineering" to turn a multitude of persons who had been bred deliberately in lazy and dissolute habits, void of decency and the sense of shame, covered with filth and vermin, and sleeping in rags, into a happy and thrifty group of workers The amazing fact is that Thompson's plans were very successful. His executive ability was so great, and his resoluteness and tact so unusual, that under his administration the seemingly impossible was accomplished His general theory was that the vagabonds would be tractable if they were first made happy and comfortable. They were to be provided with pleasant, warm rooms, given a wholesome dinner daily and provided with a chance to do remunerative work if they desired to earn a living. A circular of appeal was issued throughout Munich, Thompson himself assisting in distributing the leaflets among the principal citizens The response was encouraging Old charitable institutions—religious and secular—agreed to give up their former house-to-house canvass for funds since they were to receive the equivalent sum from the public treasury Bakers and butchers, delighted at the prospect of freedom from the beggars' importunities, agreed to contribute wholesome leftovers from their shops to the public kitchens. Thompson caused an old factory building to be thoroughly cleaned and repaired, and added a kitchen, bakehouse, dining hall and workshop[1] Carpenters, smiths and other mechanics were installed, with the request that they make and keep in order all the tools and machines which the proposed "House of Industry" might require Large halls were set aside for workers in flax, hemp, cotton, wool and worsted—each hall provided with an

[1] The Arbeitshaus and the Armeninstitut, housing these industries, are still standing in Au, a suburb of Munich.

overseer, whose duties were to give out the raw material, take in the finished work and account for the labor done. By designing efficient fireplaces, Thompson calculated that food for one thousand



COUNT RUMFORD AT THE AGE OF THIRTY

THIS PORTRAIT BY GAINSBOROUGH HAS BEEN TERMED "ONE OF THE GREAT ENGLISH ARTIST'S FINEST ACHIEVEMENTS IN HALF PORTRAITURE." IT IS REPRODUCED HERE BY COURTESY OF THE WILLIAM HAYES FOGG ART MUSEUM, HARVARD MUSEUM

persons could be cooked each day with about five cents' worth of fuel. The House of Industry was also to contain dwelling-rooms, store-rooms, a dining hall, a fulling-mill, a dyer's shop and a wash-house—everything spick and span in fresh paint.

These plans having been executed, the next problem was to collect the vagabonds! Rumford decided that the proper time for action would be the following New Year's Day (1790), nationally known as the "Beggars' Holiday." Orders were given that three infantry regiments station themselves at the street corners and that field officers and all the chief magistrates of the city be on hand to deal with each beggar who sought for alms. Rumford and his own partner set

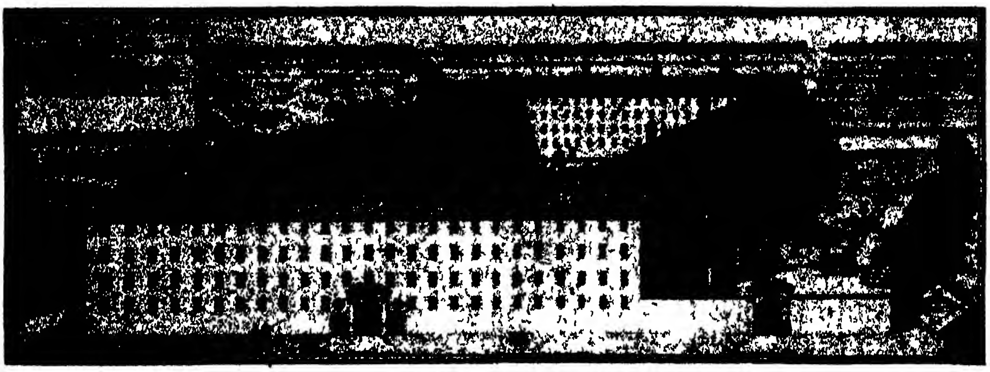


FIG 2

THE BUILDING OF THE WOOL MANUFACTORY IN AU, ERECTED IN 1679, AND EMPLOYED BY RUMFORD AS A MILITARY WORKHOUSE AND INSTITUTE FOR THE POOR IN 1789 FROM A COPPERPLATE BY WENING IT IS REPRODUCED HERE BY COURTESY OF THE GERMAN MUSEUM AT MUNICH

the example for the others by walking out on to the street, where a mendicant immediately accosted them The fellow was kindly and firmly told that from that day begging would be no longer permitted A sergeant conducted the man to the Town Hall for registration On that day 2,600 beggars were seized in Munich alone Each apprehended person was released until the following day, when he was to report to the House of Industry—with the incentive of room and board to aid him in his resolve

Rumford, created a Count as a partial reward for his services, was so successful with his gigantic administrative task that even the beggars respected him, and he enjoyed as well the support and confidence of the governing classes Most of the vagabonds so softened under good treatment that they presented scarcely any problem to the city for a number of years There was at no time a suggestion of mutiny, and the idol of orderliness, worshipped by the originator of the scheme, was so revered by the inmates that there was little friction Harsh language and ill-treatment from the overseers was not permitted. Rumford himself remarked later that "not a blow had been given to a child, while thrift had so abundantly followed from it, that even extra rewards had been granted to the deserving" Such large quantities of goods were produced by the workers that they clothed the Bavarian troops, sold to the public at home and exported to foreign lands

ORIGIN AND UTILIZATION OF DIATOMACEOUS PEAT DEPOSITS

By PAUL S. CONGER

RESEARCH ASSOCIATE, CARNEGIE INSTITUTION OF WASHINGTON, CUSTODIAN OF DIATOMS, UNITED STATES NATIONAL MUSEUM

SUPPOSE you had visions of some day building yourself a summer cottage, or of realizing nicely from the sale of shore property with gently sloping beaches, on a beautiful quiet lake in the northern woodlands In the meantime the lake has mysteriously filled up with mud and with a luxurious growth of water weeds and grass, and is disdained by vacationists and fishermen alike, and accredited only by transient duck hunters You would readily part with your holdings for a few dollars per acre to the first bidder, but withhold judgment, for perhaps this lake is worth more than your unfortunate outlook belies

Leachings of the soil over thousands of years have supported plant and animal growth in all lakes Their remains have gradually come to be deposited in the lake beds as vast quantities of organic peat, marl and other substances, which, returned to the land, have fertilizing values and properties of improving the texture and water-holding capacity of the soil Under somewhat different conditions other lakes are laying down deposits of diatomaceous earth This is a material of high commercial value for a wide variety of industrial uses, including insulation, filtration, polishing, absorption, etc Looked at in this light, lake bottoms and marshes (the filled-in beds of old lakes) comprise some of our country's richest resources, and represent assorted and concentrated materials of untold value With the application of practical and judicious methods for removing and reclaiming this wealth of material we shall still have our lakes, many of them improved and restored to their pristine beauty

The diatomaceous deposits alone concern us here That some marshes and lake bottoms may be sources of such material of great purity and high value is reputed to have been first realized when some wondering individual examined minutely the snow-white ash left as a residue of one of those subtle and devastating fires which sometimes get started in dry marshes Such fires, ignited by adjacent forest fires, volcanic lava flows, lightning or various human agencies, once started in the dry, highly organic peat of old marshes, will smoulder along unnoticed deep underground for months, or even years, until all trace of combustible material has been consumed These fires are aided by the air in the loose peat, by very inflammable marsh gases and by the momentum of their own accumulating heat Then, if the muck consisted originally only of diatoms and organic plant remains, as certain of these lake sediments do, only diatom shells remain when the organic peaty material has burned off These silica shells are very resistant and do not melt under a temperature of about 1,600 degrees Centigrade (2,800 degrees Fahrenheit), much beyond the temperature attained by such a slow-burning fire. We may well imagine the astonishment of the first observer to examine minutely this ash, on finding it to consist so purely of the shells of diatoms, sometimes to the extent of nearly 99 per cent

Imitating the procedure of this acci-

dental discovery, a well-standardized method has grown up for processing such lake muds and peats of favorable composition in order to recover diatomaceous earth. Operations of this kind are being carried on in Florida, New York and New Hampshire in this country, in the maritime provinces of Canada and in other parts of the world As is best shown in the accompanying photographs of various phases of this procedure at a Florida deposit where fine material is found, the muck is dug from shallow marshy bogs, either by hand or by dragging or pumping Hauled by a small trackway to a plant on the shore, it is formed into cakes from which excess water is pressed by a hydraulic press The pressed cakes are spread on racks to dry in the sun and air They are very light in weight when dry and can be hauled in large truck loads to a central plant Here the peat is burned, about a ton at a time, for several hours in a large incinerator, until all organic matter is burned off, leaving only the pure diatoms as a white cake. This is dumped into a large, slowly revolving tumbler, which gently breaks it up A forced draft from this apparatus carries the dust consisting of single shells and fragments through a series of air-classifying or grading chambers, where by means of cyclonic air currents the finer particles are separated from the coarser, each grade being drawn off in bags at respective points along the line

A question immediately arises—"Why resort to such an elaborate and expensive process, when mountainous deposits of very pure fossilized diatomaceous earth are to be found all through the western part of the country, clean, exposed and ready to use merely upon digging it up?" The merit of the former lies in the counter-balancing of its higher initial cost by its greater accessibility to eastern industrial markets, for diatomaceous earth is an extremely light and bulky material—a ton of it takes up a great deal of space—and the cost of shipping it long distances is often prohibitive Then, too, the ignited bog material sometimes has superior qualities for certain purposes, for "diatomaceous earth" is no longer a specific term, but various earths are found to have widely different properties, depending largely upon the species of diatoms of which they are composed The kinds comprising a given earth, as well as the purity of the material, depend largely upon the particular environment where the diatom growth and deposition have occurred Thus a very close and direct association may be drawn between the industrial application and those ecological and limnological conditions under which an earth is produced, and it is with the understanding and importance of these relationships, rather than with the commercial value of lake peat, that this article is primarily concerned It will be seen, however, that the commercial value of a deposit, its intrinsic purity and the scientific principles of its formation are all intimately related, hence it seems helpful to approach the purely scientific side of the subject from the standpoint of the industrial purity of diatomaceous sediments.

This whole study became motivated in a somewhat casual way as the result of the discovery of very concentrated diatomaceous sediments, while making general studies on diatoms in northern Wisconsin lakes during the summers 1936–38, at the Trout Lake Limnological Laboratory, upon the invitation of Dr

Courtesy of the American Diatomite Corporation

DIGGING DIATOMACEOUS PEAT

UPPER—THIS BLACK MUCK WHEN BURNED LEAVES A SNOW-WHITE POWDER OF OVER 98 PER CENT DIATOMS. CENTER—TRACK FOR HAULING MUCK, OVER SHALLOW LAKE FORMED BY ITS REMOVAL. LOWER—PRESSING EXCESS WATER FROM MUCK WITH A HYDRAULIC PRESS

Chancey Juday and Dr E A Birge, and in cooperation with the University of Wisconsin and the Wisconsin Geological and Natural History Survey

A chance collection of very rich diatomaceous mud from a small obscure lake immediately impressed the writer with its possibilities as a source of useful diatomaceous earth, and on further thought with its potentialities as a phase in the formation of fossil deposits Certain conspicuous features of this lake were noted and they stimulated an interest in the subsequent examination of other lakes for similar materials Further pursuit of the above suggested exploration led to the scientifically interesting and economically useful discovery that the lakes of this northern Wisconsin region represent diatomaceous deposition in all degrees of purity, from sediments containing practically no diatoms to others that are almost pure, with a relatively high proportion of lakes forming the more pure deposits The super-abundance of fine accessible fossil earths in the West, with minor quantities in the East, and ample production of the burned peat product, had previously detracted from any thought of such occurrences in the central part of the country In one fourth of the sixty-four lakes first examined, the material was considered sufficiently pure to be industrially important, and a number of others approached this in quality In the best deposit located, the loose fluffy sediment lay but half a foot under the surface of several acres of open water, with some square miles of surrounding marsh land that may possibly overlie equally good sediment A correspondent, Mr S M Preston, of Detroit, describes the appearance of a similar diatomaceous bog in a way that seems worthy of mention here He says, "With this material so thick in the lake to within a foot of the surface, it leaves a body of water (?) that is only a menace to life, human and animal " Such a lake contains no fish, nor little other life, and its soft but viscous mud is truly a treacherous mire to any animal that attempts to cross it or to any human that unhappily becomes involved Its only use to man is as a source of the diatomaceous earth, the recovery of which has the dual benefit of affording a useful product, and clearing the lake of the above-mentioned hazard, suiting it better to human interests, and providing once more a favorable environment for fish and other life

The muck of the best lake when dried yielded 73 per cent silica, entirely in the form of diatom shells, and largely of a small uniform type, both of which mean a high-yielding and high-grade material The additional substances consisted almost entirely of the organic matter residue of the diatoms themselves, which, when burned off, left only the useful shell portion as a fine white powder In other lakes the muck contained a higher percentage of general plant remains, but yielded on incineration an equally concentrated diatomaceous material Some other lakes in the region found to be depositing rich diatomaceous sediments are Allequash, Big, Big Arbor Vitae, Found, Grassy, Little Crooked, Little Rice, Lost Canoe, Madeline, Mann, Sweeney, Trout, Wildcat and Wolff In some the material is localized in quiet protected parts of the lake, as in Trout Lake, and in others it occupies practically the entire bottom of the lake, as in Wildcat Lake Most of these lake sediments lie under considerable depths of

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Courtesy of the American Diatomite Corporation

PROCESSING THE PEAT TO OBTAIN DIATOMACEOUS EARTH

UPPER—PRESSED CAKES OF PEAT DRYING IN THE SUN CENTER—REVOLVING TUMBLER FOR BREAKING UP LOOSE MASS OF INCINERATED PEAT LOWER—REFINING PLANT WITH BAGS OF PURE DIATOMITE, READY FOR SHIPPING

Courtesy of Dr Chancey Juday

CLAM-SHELL PEAT SAMPLER

EKMAN TYPE, WITH JAWS OPEN, READY TO LOWER

water, and consequently, in view of the large available quantities of the more accessible earth, must be looked upon as deposits of potential rather than immediate industrial value Although only a small proportion of lakes in general conform to the strict conditions necessary to the formation of very pure material of this kind, the great number and variety of lakes in northern Wisconsin, relative to the few studied, suggest the likelihood of many such deposits as yet undiscovered in Wisconsin alone, with doubtless still others in Minnesota, Michigan, New York, New England, southern Canada and similar concentrated lake regions throughout the world An additional benefit of these deposits to the northern lake territory is that of a welcome economic asset and added means of livelihood in a region that is climatically rigorous, agriculturally poor, deprived of its forest and otherwise generally deplete in natural resources Reflecting upon previous rich collections from other lakes of similar type, the writer reexamined some of these and found several lakes on Cape Cod, and one in Maryland, producing such sediments It is impossible to estimate the wealth of material which may thus be available and actively forming to-day

Conditions of the Formation of Pure Diatomaceous Deposits

The profusion and great variety of lakes in the northern Wisconsin region, together with the high incidence of such deposits, suggested a study of the circumstances under which such pure deposition takes place, the exact conditions and underlying principles of which have apparently not been stated heretofore

For this purpose the topographic and limnological features of the lakes were studied in connection with various tests on mud samples from the bottoms of the lakes Such samples were collected with the little double-jawed, steam-shovel-like clam-shell dredge illustrated in the accompanying picture This was lowered at the end of a line, with the jaws open, to sink into the soft mud Then a small brass weight slipped down the line, released a trigger which allowed springs to snap the jaws shut enclosing a mud sample Imitating, again, in the laboratory, the incineration treatment of such materials, this mud was dried, burned at several hundred degrees, examined microscopically and tested for iron, lime and other substances to determine its diatom purity

The results of this study soon gave evidence of assuming a four-fold interest. (1) The limnological conditions necessary to this type of sedimentation (2) A generalized and systematic basis for evaluating our lake deposits. (3) A series of criteria for prospecting and predicting further deposits (4) Under-

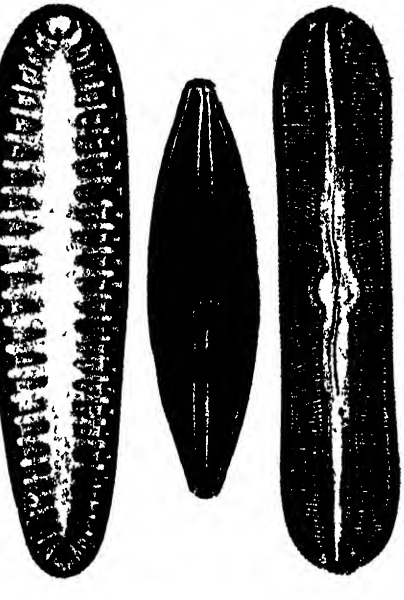
standing of the formation of our pure deposits of fossilized diatom earth

To most of us lake bottom muds superficially look very similar, brownish-black and sticky, but examined as above it is little short of spectacular to see how different is their composition, scarcely two are alike Although many sediments are a mixture of various materials, as might be expected, it is impressive to note how many lakes are forming quite pure deposits of one kind or another

Nature is a great classifier and organizer By the slow sorting of materials through differences in mass and gravity, by chemical segregation on a large scale (solution, precipitation and reaction) as the chemist does on a small scale in his laboratory, by the separation and elimination one after another of associated substances—by all these, nature achieves the accumulation of a certain material in one locality or stratum and of something else in another So the great dynamic agencies in the molten lavas within the earth have brought about the orderly separation of useful minerals Even the winds, and more especially the waters, of the earth, so frequently thought of as distributors instrumental in scattering substances far and wide, tend to operate also in bringing together like materials into an orderly grouping Heterogeneous mixtures tend to separate into groups of homogeneous materials, and order comes from chaos

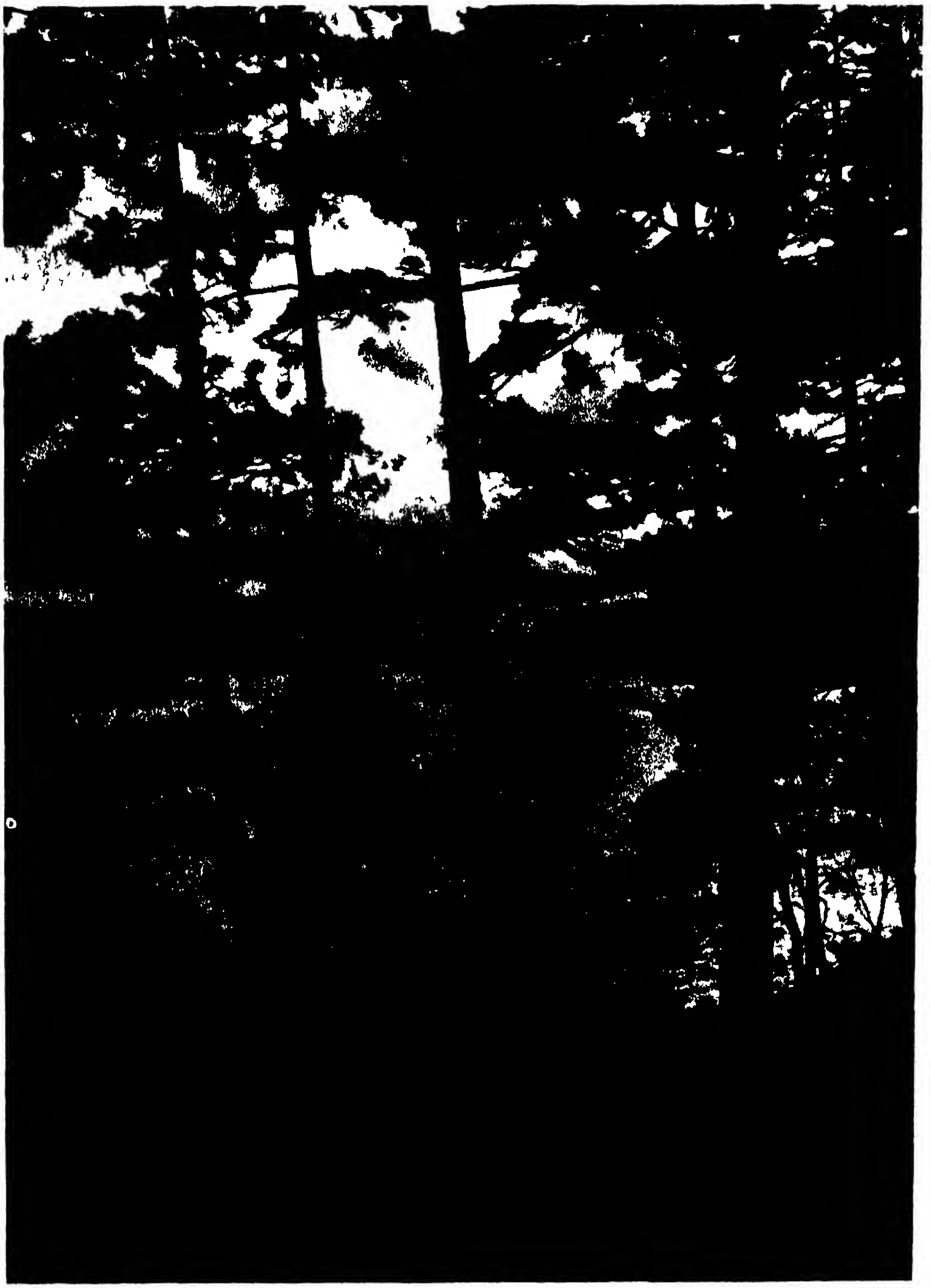
Thus one lake lays down a bed of highly calcareous marl, another accumulates an almost pure organic peat comprised of decaying plant remains, and still a third deposits only the siliceous shells of diatoms to produce a pure diatomaceous sediment What, then, are the highly discriminating conditions of such pure deposition?

One can not but marvel at the formation of beds many feet in thickness, of a



TYPICAL DIATOMS FROM LAKE MUD
SHOWING THE FINE STRUCTURE ON WHICH USE FOR FILTRATION, ABRASION, ETC, DEPENDS × 470

single material such as diatom shells These, accumulating at the very slow rate of perhaps no more than one-hundredth of an inch in a year, or less, would require thousands of years of uninterrupted deposition to form such thick beds To attain the very high degree of purity exhibited by many beds of snow-white diatomaceous earth widely distributed in the western United States, and prevalent in many parts of the world, we must realize that, throughout these long periods of time, no significant change can have occurred, no outside material can have entered, to disturb the even tenor of this process When we think of the strenuous forces of nature and the changing influences of civilization, it is hard to conceive of such long-continued periods of tranquil and unaltered sedimentation, free from intrusion of appreciable amounts of foreign materials due to dust storms or soil erosion



Courtesy of Wisconsin Conservation Department

TROUT LAKE, VILAS COUNTY, WISCONSIN

THE CENTER OF THIS LAKE HAS DIATOMACEOUS MUD AT 35 METERS DEPTH. THIS MUD IS SOFT AND GRAY WHEN DRY, AND CONTAINS 65 PER CENT DIATOM SHELLS

Indeed, it is quite probable that many lakes, which, free of these external factors, in the past, have laid down good deposits, may not continue to do so henceforth under the disturbing artificial conditions to which they are now subjected. Exceedingly small amounts of dust or eroded soil, for instance, may represent a considerable proportion of serious contamination when added to the very thin annual increment of diatom shells. In past ages, absence of cultivated areas and the presence of forest cover protected lakes from these intrusions. Only by the most stringent restrictions has nature controlled and maintained such purity of deposition over these vast periods of time. Time is a very important element.

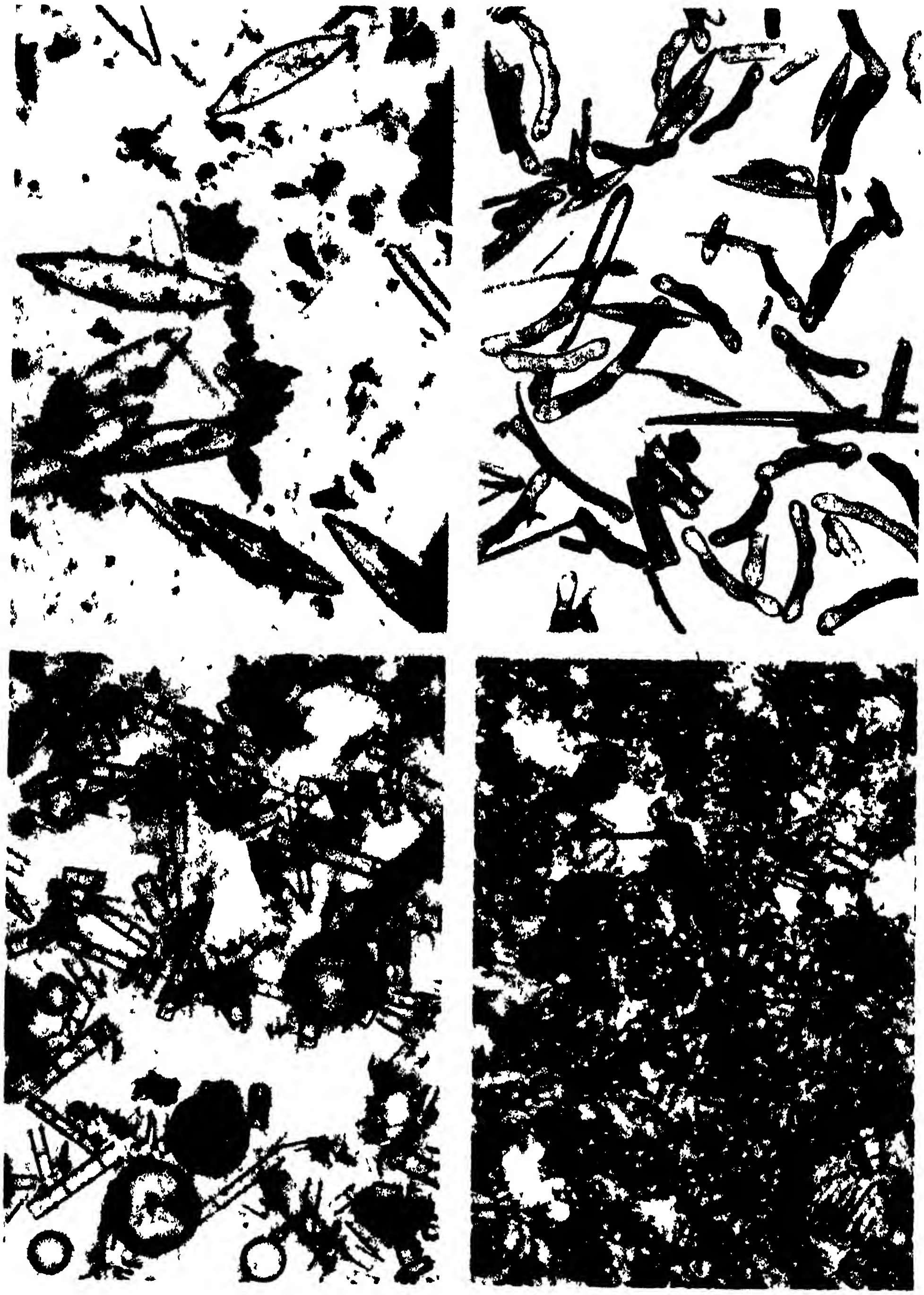
The limnological conditions requisite to the formation of pure diatomaceous sediments resolve themselves, *a priori*, into two general sets of factors: (1) those favorable to the abundant production of diatoms, and (2) those essential to the complete exclusion or elimination of all other materials. It is obvious that the presence of diatoms assures a rich diatomaceous sediment, providing all other substances are excluded or eliminated, and it is our hope here to see how this is nicely accomplished in many natural bodies of water by the beautifully adjusted association of favorable factors.

The positive condition of abundant production of diatoms is generally well satisfied and may be passed over quickly. Diatoms are found almost universally distributed in natural waters and often producing in great abundance. In these northern lakes conditions are very favorable to abundant production. The vital nutritive elements are present, with a goodly supply of dissolved silica of which the deposits are formed, the waters are cold, favoring diatoms in preference to other forms, keeping down bacteria and decomposition, and aiding solution of carbon dioxide and oxygen essential to diatoms, low decomposition and a small influx of basic elements tend toward neutral or slightly alkaline reaction favorable to diatom growth, the waters are generally clear, with good penetration of light.

It is rather the negative condition, that of exclusion of all other substances, that is more critical and less frequently satisfied. Such foreign and contaminating substances are best learned by comparison of pure with impure diatomaceous earths, and are found to be mainly of the following types: (1) Organic matter, (2) sand, silt and clay, (3) lime or magnesia deposits, (4) iron, (5) sponge spicules.

Organic matter is always present, if not as a contribution from other plant and animal remains, then purely by virtue of being a necessary constituent of the diatoms themselves. This is the case with the best bog material discovered in northern Wisconsin as described above, in which no extraneous plant remains were present, but all organic matter was that of the diatoms. Organic matter may be ignored as a serious or permanent contaminant, since it may easily be gotton rid of by burning off, and often it may even aid as a supplementary fuel in the burning process. In nature it tends to decompose and oxidize and to be ultimately removed by natural processes, leaving the pure white fossil earth with which we are more generally familiar.

Iron, likewise, is almost universally present as a constituent of the living plant or organism, and when persistent is detrimental to industrial use of the earth for many purposes. In many materials, however, it tends to be removed or transferred through the various agencies of bacterial action, utilization by further plant growth and ultimately by chemical reaction and



PHOTOMICROGRAPHS OF DIATOMITE FROM LAKE PEAT AFTER INCINERATION, SHOWING THE HIGH CONCENTRATION OF DIATOMS

UPPER LEFT—FROM OBSCURE AND UNNAMED LAKE NEAR ALDER LAKE, VILAS COUNTY, WISCONSIN × 140 UPPER RIGHT—BOGGY MARSH, CLERMONT, FLORIDA × 125 LOWER LEFT—BIG LAKE, VILAS COUNTY, WISCONSIN. × 160 LOWER RIGHT—SHALLOW HARD WATER BOG, WISCONSIN × 140

reduction in the presence of organic matter

The other contaminants above mentioned are not necessary constituents of diatom growth, and may or may not be present When present they can not be eliminated by natural processes to eventually form pure earths, nor is it feasible to use industrially an earth containing any appreciable amounts of them or to get rid of them artifically For the formation of pure diatom sediments their absolute exclusion is essential throughout entire duration of the long period of deposition

Among these, sponge spicules are the least troublesome and are seldom of real importance Very occasionally a layer with a high concentration of sponge spicules will be found Sponges are sensitive and restricted to a slow and limited growth in a very narrow environment, their spicules are relatively heavy and not easily transportable, hence their contribution to most sediments is negligible

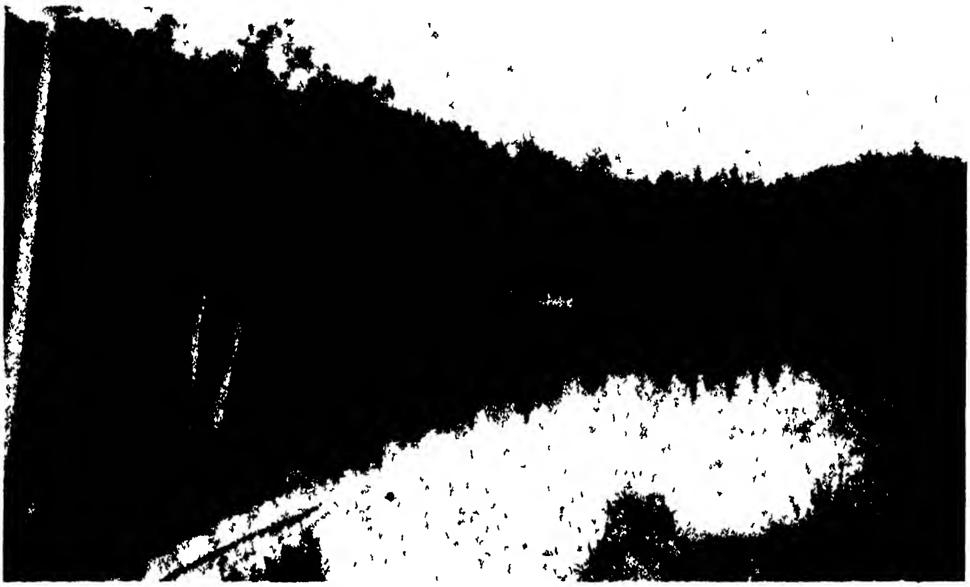
Sand is rarely a factor in diatomaceous deposits Because of its relatively much greater weight, water currents usually effect the deposition of sand and diatom shells in quite separate locations

Elimination of the foregoing reduces our list of possible contaminating materials to lime, silt and clay, which are by far the most common and most troublesome sources of contamination

Lime or marl is formed by lime-secreting plants or animals from calcareous matter in solution, brought in by inflowing drainage waters When these waters do not drain from a limestone region and consequently do not carry calcium in solution, as is the case in many of the northern Wisconsin lakes, lime is naturally absent from the sediments This is no more strikingly demonstrated than by comparing the northern lakes with Mendota and Oconomowoc Lakes, which lie in the limestone region in southern Wisconsin In these latter lakes diatom production is, if anything, more prolific than in the nutrient-low northern lakes, but marl is also deposited, rendering the sediments correspondingly low in diatom content and economically worthless Its exclusion is simple and complete under the proper drainage conditions as mentioned

Neither so simple nor so certain is the complete exclusion of silt and clay Having much the same relative density as the diatom shells, they are both difficult of exclusion and impossible to eliminate These materials are almost universally distributed, and they are accessible to lakes through varied and changing agencies of influx, such as dust storms, soil erosion or dynamic disturbance of the lake basin itself To prevent intrusion of these substances conditions must be such as to protect the lakes from their sources, and a study of many lakes has revealed the fact that physiographic and environmental features of lakes are chiefly instrumental in this respect Thus small- to moderate-sized lakes surrounded by gentle hills and forest cover are protected from the sweep of high winds which may otherwise agitate the water sufficiently to stir up silt from the lake basin itself Run-off and soil erosion are retarded by vegetation cover, and a surrounding forest minimizes the influx of air-blown detritus Marginal growth of wild rice and other aquatics growing in shallow lakes is very effective in inhibiting agitation and transfer of sediments In larger lakes, in central or deeper areas far enough removed from zones of water agitation to be protected from transported detritus, there may also be laid down very pure diatom sediments under conditions which would seem superficially quite unfavorable This is the case with Trout Lake in Vilas County, Wisconsin

The delicacy of adjustment of this whole set of conditions lies in the fact



Courtesy of Dr Chancey Juday

LAKE MARY, VILAS COUNTY, WISCONSIN

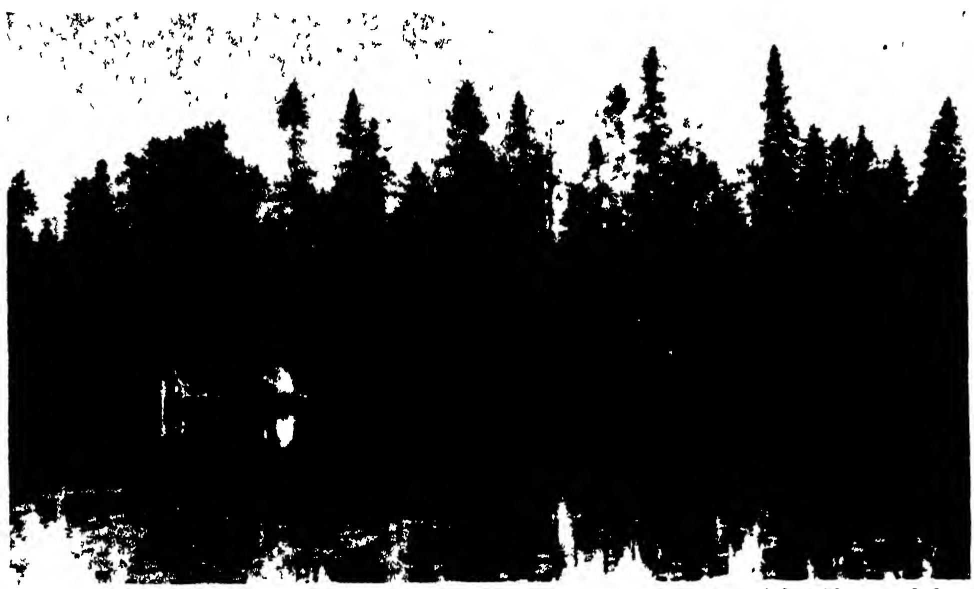
A TYPICAL HARD WATER LAKE SUCH AS MAY DEPOSIT DIATOM SEDIMENTS THIS TYPE OF LAKE FORMS PEAT CONTAINING A HIGH PROPORTION OF DIATOMS.

that while clay, silt and lime must be kept out, and iron avoided, an ample and continuous supply of silica in solution must be brought into the lake waters, for this is the material of which the diatomaceous sediments are built Calcium and silica alike are brought into a lake in solution in drainage waters, utilized by organisms in building up their bodily structure and precipitated irreversibly when they die, as a deposit The source of the silica is necessarily an external one, *i e*, the soils of the surrounding terrain, which, hence, must be siliceous, and free of lime As has been said, when lime (or calcium) is abundant a marl deposit is formed, and it is only when lime is absent from the drainage area that a pure diatomaceous sediment is free to accumulate

Clay and silt are almost invariably coincident with the source of silica, and the waters which bring in the silica in solution must not carry in particles of the former. This is achieved in several ways which are intimately associated with the physiographic features of the lake basin Outstanding physiographic features of the region are the fact of glaciation and the presence of springs, and it will be interesting to see how these are associated with the formation of pure diatomaceous sediments

Early in the investigation it was recognized that springs are very closely related to rich diatom production Several conspicuously fine shallow water sediments were underlain by springs To one's hand, the half a foot of water above the fluffy gray mud was very warm in the summer sun, but when the hand was plunged a half a foot below the surface of the muck an icy cold temperature was encountered

Of the two general types of waters that feed a lake, surface inlets or run-off and springs or seepage waters, the latter are of distinct advantage in every respect, as may be seen by the following comparison.



Courtesy of Dr Chancey Juday

FORESTRY BOG, VILAS COUNTY, WISCONSIN

A TYPICAL SOFT WATER ACID LAKE, PRODUCING DIATOMS, BUT LAYING DOWN DEPOSITS PROPORTIONATELY LARGE IN ORGANIC MATTER

Study of the characteristics of a large number of springs indicated that while they contribute abundantly of dissolved silica, this contribution is made through the undisturbing addition of cold water (filtered free of silt, clay and detritus) to the bottom of the lake, bringing in no contamination This is quite in contrast to the heavy load of silty material which inflowing streams gather from run-off and soil erosion, and often bring in from upland areas to spread out through the surface waters of a lake, whence it may sift down and contaminate all sediments Spring and seepage waters filter slowly in intimate contact with the soils through which they pass, and numerous analyses of spring waters by Birge and Juday show that their dissolved silica content is several times as high as that of the lake waters which they feed

Though springs are thus the ideal method of supplying silica and nutrient salts with the exclusion of all detritus, surface drainage waters may, under favorable circumstances, fulfill the same function, though never with the absolute discrimination of the former Sluggish streams, filtered through growths of wild rice or higher aquatics about their mouths, may often be efficient in bringing in clean nutrient-bearing waters

The passage of the ice sheets over this region has been either directly or indirectly responsible for many of the conditions favorable to formation of pure diatomaceous sediments Glaciation has been of major importance in the following ways

(1) Formation of innumerable lakes, which serve as places for production and deposition of diatoms

(2) Arrangement of the topography in such an apparently disordered fashion as to inhibit development of large and highly erosive drainage systems

(3) Formation of large numbers of seepage type, spring fed lakes

(4) Protection of lakes from wind erosion and water agitation by chaotically placed hills

(5) Formation of lake basins from material consisting of ground igneous rocks and siliceous

SELECTED GROUP OF CHARACTERISTIC DIATOMS FROM A BOG PEAT ×150

sands transported from the north, with finer soils and lime washed out, this material peculiarly favors diatom production—silica is abundant, lime is scarce

(6) Providing thus, by their sorting action, lake basins in a coarse grained porous substrate, pervious to abundant springs and seepage waters, drainage systems have been inhibited, springs and seepage waters have been given advantage

(7) With preference to seepage waters, the favorable conditions of springs are realized—cold waters, free of detritus, low in bacteria, neutral or slightly alkaline, feeding from the lake bottom with no disturbance

Though glaciation has greatly enhanced the production of diatomaceous sediments in this region, as stated, it is by no means indispensible in such formations Application of the same underlying principles indicates that identical results may be derived in a number of somewhat different ways, but following essentially the same analytical process by which nature sorts and separates these materials

In Florida, not reached by the ice sheet, for instance, lakes abound in flat or slightly rolling country, their basins formed in siliceous sands overlying a hard coral sub-stratum They are well

protected by wide stretches of flat or slightly rolling land covered with prolific vegetation, and drained by few or sluggish streams Their bottoms are perforated by innumerable springs and fed by cold silica-bearing artesian waters, originating in higher regions of the coastal plain

In Greenland and Alaska, and similar regions, cold waters from melting glacier fronts drain over igneous materials, to produce in the lower waters of quiet protected fiords a prolific growth of diatoms which settle to form pure deposits

Likewise, small clean mountain streams in the West arising from melting snows and ice have brought into dammed-up valleys and crater lakes material suitable for production of many rich deposits

All phases of the general subject of the conditions of pure diatomaceous deposition, as applied to both actively forming and fossil deposits, are being considered in detail in a monographic treatment now being prepared

It is manifest that experience and familiarity with the principles of this process may aid in locating and recognizing lakes in which active deposition of this type is now going on As a matter of fact one can stand on the shore of a lake and almost predict the presence or absence of such deposits On the basis of the facts before us it is possible to formulate an ideal environment for the formation of such pure deposits, as that of a small to moderate-sized, rather shallow, cold, spring-fed, seepage-type lake, lying in a coarse siliceous-sand or rock basin, filled with reeds or marginal aquatic growth, and well protected by isolation in broad, flat, vegetation-covered country, or surrounded by forest-covered hills

It is amazing that there are so many diatomaceous deposits of such very high purity, and yet, when we view the precision and constancy of these processes of nature it is perhaps equally amazing that there are not more of them

CHANGES IN SHOSHONEAN INDIAN CULTURE

By Dr JULIAN H. STEWARD

SENIOR ANTHROPOLOGIST, BUREAU OF AMERICAN ETHNOLOGY

When, in 1843, Colonel John Charles Frémont crossed the Rocky Mountains and entered the semi-arid, sage-covered deserts of the Far West, he wrote of the Indians "From all that I heard and saw, I should say that humanity here appeared in its lowest form and in its most elementary state Dispersed in single families, without firearms, eating seeds and insects, digging roots such is the condition of the greater part" These Indians are now known as Western Shoshoni, Northern Paiute and Southern Paiute They are divisions of the Shoshonean linguistic family which occupied the plateaus and Great Basin between the Wasatch Mountains in Utah and the Sierra Nevada and Cascade Ranges of California and Oregon

Ethnographic study in recent years has confirmed the unanimous opinion of explorers, trappers and pioneers that the Shoshoneans were indeed impoverished The greater part occupied a semi-starvation area where they subsisted upon seeds, roots, rabbits, gophers, snakes and even insects more than upon large game Necessity compelled them to remain in small groups, single families often wandering about alone in search of food When their slender resources failed, starvation was common and cannibalism not unknown Their material arts and industries were simple During most of the year they lived in crude, improvised shelters and windbreaks Their clothing, if they wore any, was often made of sage bark or rabbit skins By any standard, they were underprivileged

But two groups of Shoshoneans were, upon the arrival of the white man in the West, living in a manner that contrasted sharply with the lowly condition of those just mentioned The Northern Shoshoni of eastern Idaho and of western Wyoming were organized in large bands which traveled on horseback, hunted bison and fought their traditional enemies, the Blackfoot and Arapaho Their fine appearance and military prowess commanded the respect of both white men and Indians The Ute of eastern Utah and western Colorado, also members of the Shoshonean family, were similarly organized in well-mounted bands of hunters and warriors Both tribes subsisted to a large extent upon bison, which they generally took east of the Rocky Mountains They owned tipis, dressed in skin garments and lived with an elegance far more like that of the tribes of the Great Plains than of their own poverty-stricken relatives to the west

This extraordinary difference between neighboring and closely related members of the Shoshonean family was not brought about by any native ineptitude on the part of the Western Shoshoni and Paiute nor by any special genius of the Northern Shoshoni and Ute It was the result of an entirely understandable interaction of culture and environment, the broad outline of which can be traced for more than 1,000 years

Three economic events are outstanding in Shoshonean history First, they acquired the techniques and devices for procuring food that made life possible in this environment Much later, a portion of them acquired horses from the Spaniards who had settled the Southwest and experienced fundamental changes in certain of their customs Finally, modern civilization reached them The profound effect of these economic changes, especially in shaping and delimiting their social and political pat-

terns, underlines the importance of human ecology among hunting and gathering peoples.

The main food resources of the Shoshonean environment are small, hard-shelled seeds and small game Large game animals were so scarce that the population of any people whose subsistence was based primarily upon hunting must have been extremely sparse The most effective exploitation of the seed resources under primitive conditions called for a knowledge of basket weaving and the manufacture of certain special forms for the different steps in gathering and preparing seeds To procure rodents and other small game in important quantities, a knowledge of certain traps, nets and snares was necessary

Of pre-basketry people in the Shoshonean area, archeology has revealed only the slightest traces The archeological record really opens with the Basket Maker Indians, the predecessors of the Pueblo Indians, who occupied southern Utah and northern Arizona in the early centuries after Christ To them must go the credit for solving the problem of subsistence in the desert, for they are known to have used all the essential hunting and gathering techniques employed by the modern Shoshoneans They constructed large, conical baskets for gathering wild seeds, basketry trays for winnowing them and for parching them with live coals, flat stone slabs (metates) for grinding them and basketry bowls for boiling them They even made tight baskets in which to carry water on their excursions into the deserts They used long nets into which they drove rabbits and made snares and traps for catching smaller rodents They learned to weave robes of twisted strips of rabbit fur and of bird skins and to make sandals of vegetable fibers Without these techniques, life must have been extremely difficult in this country

The Basket Maker Indians were not widely distributed through the West, but their entire economic complex, with the exception of maize farming, which they carried on in a small way, spread to the ancestors of the Shoshonean Indians who were then occupying the western portion of the Great Basin Archeology of western Nevada provides the connecting links between the Basket Makers and Shoshoneans A large cave contains stratified cultural deposits cov-

NEVADA SHOSHONI MAN, 1936

WESTERN SHOSHONI WOMAN, 1936.

TYPICAL SHOSHONEAN HABITAT
SAGE COVERED VALLEYS AND PINYON AND JUNIPER COVERED HILLS OF SNAKE VALLEY, NEVADA

UINTAH UTE TEPEE IN NORTHEASTERN UTAH
PHOTOGRAPHED BY HILLERS, POWELL EXPEDITION, 1873

ering more than 1,000 years Objects from the lowest stratum include hunting and gathering devices and clothing which are almost identical with those of the Basket Makers Those from overlying strata, left during subsequent centuries, show slight readaptations of the economic complex, which, in the latest deposits, becomes specifically like that of the modern Paiute of this region

The Shoshoneans, however, did not spread throughout the intermontane deserts until several centuries after acquiring the Basket Maker hunting and gathering techniques The archeology of Utah and eastern Nevada shows not a trace of either Shoshoneans or Basket Makers In fact, there is little evidence of any people until about 1,000 A D, when this area became dotted with small villages of farmers, who subsisted on maize and squash This farm culture, including many features, such as house types and pottery, had sprung from that of the Pueblo Indians, who succeeded the Basket Makers in the Southwest It had spread up the Colorado River and its tributaries and along the fertile piedmont of the Wasatch Mountains But it did not endure long After one or two centuries, the farmers were beset by trouble Perhaps several factors conspired to their undoing, but one stands out Warfare of some kind was forcing them to build their latest habitations in fortified and inaccessible locations Possibly they fought with each other More likely, new-comers to the area were at least partly involved We know that a group of hunters entered the Great Salt Lake Basin at this time and took up residence in caves The Pueblo Indians soon disappeared, and shortly thereafter the hunters also vanished The fate of both peoples is a mystery, but it is certain that neither was related in any way to the Shoshoneans

IDAHO SHOSHONI SUN DANCE, 1926

The archeological record for the next 700 or 800 years is, except for western Nevada, largely a blank There is no doubt, however, that during this time the Shoshoneans, whose artifacts and houses are of such a perishable nature that they ordinarily leave little archeological evidence, were spreading out into territory which they occupied at the opening of the historic period The Northern Paiute spread throughout western Nevada and

MODERN CHIEF OF THE UINTAH UTE

penetrated eastern California and southeastern Oregon. The Shoshoni came to occupy the territory from Death Valley, California, through central Nevada and southern Idaho to western Wyoming The Comanche, who later moved to the southern Great Plains, probably formed a single group with the Wyoming Shoshoni It is remarkable that the Comanche language to-day is almost identical with that of all Shoshoni, including even those of Death Valley The Ute expanded throughout former Pueblo territory in most of Utah and western Colorado, while the Southern Paiute, whose language is very similar to that of the Ute, occupied southern Utah, southern Nevada and even some of northern Arizona and southern California

Prior to the introduction of the horse to the eastern portion of this area, all Shoshonean culture was "low" or simple Probably no primitive tribe in the world in recent centuries possessed fewer material goods and utensils nor more elementary social, political and religious customs Isolated in their deserts from contacts with higher cultures after the Pueblo Indians were driven out, impoverished in material wealth and forced to subsist on a meager fare of rodents and sparsely growing seeds, their native condition gives a very vivid picture of human society devoid of elaborations and embellishments and stripped to an almost irreducible minimum It does not, however, represent any "stage" of social development Each group of human beings has had its own somewhat distinctive history Although Shoshonean society shared certain basic features with all

ANCIENT TECHNIQUE OF FIRE MAKING DEMONSTRATED BY NORTHERN PAIUTE

mankind, its special form was the result of having to support existence in certain environment by means of a specific economic complex

As among all peoples, the molecule of Shoshonean society was the family It consisted of the father, mother, children and perhaps grandparents and aunts and uncles Sometimes a man had two wives Sometimes, also, a woman had two husbands But social and political ties transcending those of the family were infrequent and unstable There were no clans, no close-knit bands, no true tribal units, and, in fact, no men who could properly be called chiefs—a state of affairs explained by the exacting nature of Shoshonean subsistence activities

Shoshonean life was devoted almost exclusively to the unrelenting demands of the food quest Vegetable foods provided the main staples In early spring, when stored foods were exhausted and hunger was acute, each family left its winter encampment to forage through a country of perhaps 400 to 500 square miles First, it sought greens in the mountains Later, it wandered through the foothills or through the scorching and dry deserts to gather seeds, carrying water in pitch-coated basketry jugs Persons who were too old or too infirm to travel were made comfortable, given water and such food as could be spared, and left behind to perish While women gathered seeds and tended to their children, whom they were often compelled to carry on their backs along with the general baggage, men hunted mountain sheep, deer, antelope, rabbits and ro-

SOUTHERN PAIUTE WOMAN
ON THE KAIBAB PLATEAU, NORTHERN ARIZONA, WITH CONICAL SEED BASKET PHOTOGRAPH BY HILLERS, POWELL EXPEDITION, 1873

UINTAH UTE IN UTAH
PHOTOGRAPH BY HILLERS ON THE POWELL EXPEDITION, 1873

Webster McBride photo

ERECTING THE CENTER POLE OF THE SUN DANCE LODGE, UINTAH UTE

dents Game was sought not only as a welcome ingredient in the pot of seed or root mush but as a source of skins for garments and other essential articles

In the course of these wanderings, a family often encountered other families on a similar quest But it was usually hazardous for them to remain together for more than a few days, because nature was so parsimonious in her distribution of seeds that few regions afford a supply ample for large numbers of persons This explains why the early explorers usually met only single families or small groups of Shoshoneans, trekking wearily from place to place on foot and carrying

UINTAH UTE WARRIOR AND BRIDE

PHOTOGRAPHED BY HILLERS, POWELL EXPEDITION, 1873

MODERN ADAPTATION OF SHOSHONI BRUSH SHELTER
FT HALL RESERVATION, IDAHO, 1936

their entire household equipment on their backs

In the fall, however, nature was usually somewhat more bountiful when the nuts of the pinyon (*Pinus monophylla*) ripened This nut was the most important species of all Shoshonean foods throughout the greater part of Utah and Nevada Where harvests were good, large groups of people foregathered to dance, gamble and visit with friends and relatives whom they had seen rarely if at all during the remainder of the year But these activities lasted only a few weeks The harvested nuts had to be carried to a locality with firewood and water suitable for a winter residence Here they erected a pole and brush lodge

PAIUTE BRUSH HOUSE
ADAPTATION BY MODERN NORTHERN PAIUTE IN EASTERN CALIFORNIA OF ANCIENT SUMMER HOUSE

SOUTHERN PAIUTE WITH BOW AND ARROWS
NEAR LAS VEGAS, NEVADA PHOTOGRAPH BY HILLERS IN 1873

and stored the seeds nearby If the pine nut yield had been good, they lived in comparative comfort during the winter, if not, many of the old and infirm, weakened by hunger, died

People preferred to winter always in the same locality, which they considered home and where they might be near a dozen or more families of friends and relatives. Often, however, good crops of seeds, especially of pinyon nuts, occurred in very unpredictable localities from year to year If a good crop were far from home, a family had no choice but to travel to that locality and make its winter home near the seed supply This erratic occurrence of seeds, more than any other factor, prevented the formation of permanent associations and allegiances between Shoshonean families

When gathering seeds, there was no way in which several women could cooperate to increase their production In fact, each woman was likely to procure less if too many women worked in the same seed patch Hunting, however, was different A group of men hunting cooperatively could take several times as

SEPARATING THE CHAFF FROM SEEDS
NEVADA SHOSHONI WOMAN USING THE WINNOWING BASKET

much game as an individual hunter. Consequently, when enough men happened to be in the same vicinity and when game was sufficiently abundant, men joined in communal drives and shared the kill. Drives, however, were rarely profitable for more than a few days or a few weeks.

The most important drives were for antelope and rabbits. Antelope drives were under the charge of antelope shamans or "doctors," whose supernatural power was believed to be indispensable to the success of the drive. First, however, as an essentially practical device, the shaman directed the construction of a corral of juniper poles, having a gate to which two long fences converged. When this was ready and when antelope were known to be in the vicinity, the shaman undertook to render them docile and stupid by means of his power. Through singing and other measures, he captured the animals' souls, whereupon, bereft of their sense, they wandered helplessly—though usually encouraged by hunters from behind—into the corral where they were killed. Deer were sometimes also captured in drives aided by the shaman, though more often they were hunted in

SOUTHERN PAIUTE SUMMER SHELTER
IN SOUTHWESTERN UTAH PHOTOGRAPHED BY HILLERS, POWELL EXPEDITION, 1873.

a purely practical way Rabbit drives were always a lay business Several long, low nets (identical with specimens found in Basket Maker caves) were placed end to end in a huge semi-circle. A crowd of people then beat the brush, driving the animals before them into the nets and clubbing them to death Along certain rivers, especially in the Snake River in southern Idaho, families sometimes cooperated in communal fishing enterprises.

ANCIENT TYPE OF BRUSH LODGE.
USED BY MODERN SHOSHONI FOR A DOG HOUSE. FORT HALL RESERVATION, 1936

Communal pursuits, however, were too short-lived to take up the slack in Shoshonean society Husbands and wives always remained together, carrying on their respective and complementary economic tasks and caring for their children But allegiances between families were transitory Pinyon nut harvests, communal hunts and occasional brief fiestas or dances during periods of unusual abundance of certain foods were the only affairs which were cooperative The same families did not always participate in these It could not have been otherwise so long as Shoshonean subsistence was limited to hunting and gathering with the few technical aids—baskets, grinding stones, bows and arrows, traps and nets—at their command

The Northern Shoshoni and Ute had already had the horse for many years when first visited by the white man and exhibited a very different state of affairs The exact date of the introduction of the horse is not known, but there is no question that it came originally from the Spaniards who had settled the Southwest About 1730, Wyoming Shoshoni warriors, having the advantage of being mounted, routed their Blackfoot foe, who had not yet acquired horses In 1806, Lewis and Clark saw many horses among Shoshoni on the Lemhi River in Idaho Horses were probably transmitted from the Southwest through the Ute Indians of Colorado and Utah who, at Escalante's visit in 1776, seem to have possessed them Thus, by the early part of the nineteenth century, when trappers and explorers began to open up Shoshoni and Ute territory, horses were fairly numer-

ous They had not, however, spread into Western Shoshoni and Paiute territory because the grasslands are too limited in the Western deserts

We have no eye-witness account, of course, of what the Northern Shoshoni and Ute were like before the introduction of the horse Very likely the Wyoming Shoshoni, who lived in bison country east of the continental divide, were much like other Plains tribes The other Shoshoni and Ute, however, must have been very similar to their kin to the west

The story of the horse in the western Great Plains has often been told It wrought important changes in Plains Indian culture, but these were in the direction of intensification of pre-existing patterns rather than innovation It facilitated bison hunting, increased warfare and generally heightened the tempo of all activities Introduction of the horse to the Shoshoneans completely revolutionized certain fundamental patterns It opened entirely new possibilities for food getting, laying a foundation for social and political forms which had previously been impossible It brought cultural contacts which resulted in the acquisition of many new customs And it was responsible for clashes with Plains tribes which implanted a militaristic spirit

While having to travel on foot in pre-horse days, the Northern Shoshoni and Ute were no doubt essentially seed gatherers, living in small groups like their relatives to the west Some bison occurred in both Idaho and Utah, but they were limited in number and became extinct at an early date The introduction of the horse freed these Shoshoneans from the necessity of wandering tediously each year through a restricted terrain in search of vegetable foods and assured them an ample supply of meat Communal hunts on horseback were vastly more efficient than drives on foot Moreover, it was now possible to travel into country where game was far more numerous than at home. The earliest records show that seasonally the Ute and Shoshoni left their deserts and crossed the Rocky Mountains to hunt the great bison herds on the high plains The Wyoming Shoshoni were, of course, better situated, having no great distance to travel

But the horse had another and more important effect upon social groups The

WESTERN SHOSHONI WOMAN
WEAVING BASKETRY BOWL, 1931 STIMULATED BY CONTACTS WITH CIVILIZATION, THE BASKETRY ART HAS IMPROVED AMONG SHOSHONI IN THE REGION OF DEATH VALLEY

number of people who can live together in the same community depends upon their ability to concentrate their foods at a central point So long as they must transport everything on their own backs, they are more likely to settle near their foods than to attempt to carry their foods 25 or 50 miles to a central village The horse solved the transportation problem Bison meat and, in fact, such other foods as seeds, berries roots and fish were

A DEMONSTRATION NATIVE DANCE
A MODERN PAIUTE MAN OF EASTERN CALIFORNIA

transported by horse to large, central encampments where several hundred people wintered together. Many Idaho Shoshoni, for example, often traveled hundreds of miles into Wyoming to hunt bison or to western Idaho to trade bison skins for salmon and then returned to the vicinity of Fort Hall to spend the winter.

But this new freedom and security from starvation also carried a penalty. Hunting in the Great Plains brought the Shoshoni into conflict with the Blackfoot and, during certain periods, with the Crow Indians. In fact, the Wyoming Shoshoni had been enemies of the Blackfoot in pre-horse days. The strife was occasioned not so much by competition for hunting land as by a fundamental love of warfare which had infected many of the Plains tribes. War parties set forth to gain honors by counting coup, taking scalps and stealing horses. The Shoshoni were never safe during their bison hunts. But they too succumbed to the lure of warfare, and their own young men set forth on war parties often for the sole purpose of achieving distinction. If things became too hot on the Plains, they retired to the comparative safety of their deserts, where the Blackfoot raiding parties seldom dared carry the fight.

Warfare furthered the social and political cohesion which the horse and bison hunting had made possible. Large groups of families not only set forth on hunting trips together because of the advantages of communal efforts, but remained together for protection against raids. As these activities required some kind of supervision, certain leaders rose to great prominence. In short, previously scattered and independent families became amalgamated into bands under chieftains.

The bands, however, were never permanent, and the authority of the chiefs was neither absolute nor hereditary. Instead, influential men attracted a following, the size and permanency of which was extremely variable. Some wielded enormous power, like Chief Washakie of the Wind River Shoshoni in Wyoming, whose influence controlled not only his own people but extended into Idaho and Utah. Chief Ouray similarly commanded the respect of a large portion of the Ute. Other men often gained a con-

siderable temporary following only to have it disintegrate into a number of small bands

In addition to bringing about this development of band organization among Northern Shoshoni and Ute, the horse facilitated the introduction of many new customs Having greater material wealth, especially in bison skins, and better means of transportation, people largely abandoned pole and brush houses for skin tipis They ceased to make sage-bark shirts and rabbit-skin blankets and wore complete skin shirts, leggings, dresses and moccasins, all modeled on Plains styles They largely abandoned their basketry and made bags and containers of rawhide like those of their neighbors on the Plains And they learned the manufacture of shields, spears, clubs and other war paraphernalia and adopted the elaborate system of war honors and ritual of the Plains Indians More recently, they even instituted the Sun Dance, a typical Plains performance

Meanwhile, the Western Shoshoni and Paiute remained at a primitive level The Southern Paiute adopted a small amount of horticulture from the Pueblo Indians, but it never became an important factor in their economy When the white man arrived, they stole his horses, but instead of using them as the Northern Shoshoni and Ute had done, they ate them The horse, in fact, never became important to the Western Shoshoni and Paiute because their territory was deficient in grazing lands Instead of expediting hunting in this area where there was little to hunt, horses would merely have eaten the very seeds and grasses upon which people relied

The Western Shoshoni and Paiute remained substantially unchanged until nearly 1860 By this time, immigrants had taken up their best food lands and shot their game Live stock, ranging widely over the country, had seriously reduced the quantities of wild seeds Suffering acutely from food shortage, the Indians attempted to drive the white man out Equipped now with a few horses, people, who had previously moved about independently, rallied under war leaders, and fighting broke out in various places in Nevada, Utah, eastern Oregon and Idaho But these struggles had no chance of success and within a few years were subdued, the Shoshoneans' native period now at an end. Since that time, they have either attached themselves in small groups to ranches or towns in their former territory or have moved to reservations Absorption of the white man's customs has advanced rapidly because it has been essentially a process of adding to rather than replacing native customs Little to-day remains of aboriginal life except in the memories of the old people

THEORIES OF FORMATION OF ORE DEPOSITS

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MANY of the early speculations concerning the origin of ore deposits contain hardly the slightest element of truth and are so enmeshed with astrological theories or colored by religious concepts as to be of no significance in a scientific discussion, however illuminating they may be as a record of the development of the human mind from lethargy to credulous activity and finally to critical alertness. For this reason and also to bring our discussion within the allotted pages it will be necessary to neglect historical backgrounds and to attempt simply to picture in broad strokes the present concepts concerning the origin of ore deposits This picture, though drawn mainly for the reader unfamiliar with geology, may be of interest also to some geologists as emphasizing the intimate dependence of applied geology upon what we are pleased to call pure geology.

Although in this discussion we shall construct a classification of ore deposits it is wholesome to remember at the outset that however fond we may be of subdividing our knowledge into classes and constructing definitions of the classes these are merely devices for our own convenience, concessions to our ignorance, tricks to simplify our thinking They are pedagogical misrepresentations of nature's ways, forgivable and useful in the limited state of our powers but having no counterpart in nature herself whose dominant notes are unity and integration, not division and isolation.

Although we commonly think of an ore as different from a rock in the sense in which "rock" is usually used, actually all ores are rocks and the boundary between them is drawn not by the geologist but by the business man at the commercial limit of profitable exploitation. A cheaper method of mining or treating or transporting nature's metal-bearing materials may shift a common rock into the category of an ore The general trend of improved technology has been to make possible the use of lower and lower grade materials It is customary and convenient to restrict the term ore to rocks that contain the metals or their compounds in workable amounts and we shall concern ourselves here only with ores in this sense Many *non-metallic* elements and their compounds also find commercial application and some of them have been formed by processes similar to those involved in ore formation Occasionally some uncritical writer jumps the terminology fence and refers to some deposits of the non-metals as ores, such as graphite "ores" or fluorspar "ores."

What seem to-day to be sound concepts of the origin of ores waited for their development upon the laying of a firm foundation of knowledge of the processes by which the commoner varieties of rocks have been formed In particular there was necessary the clear recognition of the two great processes by which rocks are formed, namely, vulcanism and sedimentation, and the defining of the criteria by which the *igneous* rocks formed by the processes of vulcanism could be distinguished from the sedimentary rocks So long as great bodies of igneous rock were misinterpreted as deposits laid down on the ocean's floor, as commonly happened up to the beginning of the 19th century, little progress was possible in the interpretation of ore formation, for upon this distinction hinges the subdivision of ore deposits into their two main categories.

Although we have stressed the fact

that ores are distinguished from the common rocks by their larger metal content, this statement if left unqualified would give too simple a concept of their relationships. It must also be understood that ores are a subordinate and very exceptional variety of rock constituting only a small fraction of one per cent of the total body of rock that makes up the earth's surface. This is readily realized when we recall that large areas of the earth's surface, some of them half a continent in extent, are devoid of any ore deposits This is true, for example, of most of northern Africa and of the interior of Australia Obviously the formation of ores is very much less common than the formation of the common rocks and tends to be localized in certain regions

A second point of great significance is that as a rule the metal content of the common rocks is extremely small as compared with the metal content of even our lowest grade ores Thus it has been estimated that the average amount of copper in the common igneous rocks is about 01 per cent whereas 1 per cent may be taken roughly as the minimum amount in workable copper deposits, a ratio of 1 to 100 In the case of most other metals the contrast would be even more striking There is, therefore, a sharp jump in the metal content in passing from the common rocks to those rare rocks that we call ores. These two facts, the relative variety of the ores and their relatively high metal content, clearly show that in the formation of ores some process of natural concentration has been operative, converting, in restricted areas, materials poor in metals into small but rich ore deposits

From what has been said the reader will surmise that our present knowledge of the processes of ore formation has been acquired *pari passu* with our knowledge of the processes by which the common rocks have been formed and later modified. Almost every process by which the common rocks may be formed or modified finds its counterpart in some process of ore formation, and a list of the processes of ore formation becomes virtually a classification of all geologic processes.

It becomes evident, therefore, that ores may be formed by many and very different processes, and the situation is further complicated by the fact that several of these processes may cooperate, simultaneously or in turn, in the formation of a single ore deposit In the following pages we shall try to analyze this seemingly complex situation into its simple elements

What is the nature of those natural processes of concentration by which ores have been formed? The first great group of processes that may produce such concentrations are those associated with the attack of the air and of the waters of surface origin upon the rocks The realm of action of these processes is widespread, being indeed coextensive with the land surface, but of shallow depth, being restricted to the few hundreds of feet to which the air and surface waters can penetrate the cracks and pores of the rocks in significant amounts The effect of these processes is to wear down, or "degrade," certain parts of the land surface, but the material thus worn away must obviously be deposited elsewhere to build up, or "aggrade," other parts of the land surface or the bed of the ocean The entire process, first degradation and then aggradation, is termed by the geologist "gradation " The first great class of ore deposits, and by and large the class most easily recognized and understood, is the deposits formed by gradational processes.

Ore Deposits Formed by Gradational Processes

The various ways in which ores may be formed at or near the surface by processes of gradation may be most readily

understood if a few representative instances are cited. In the Mayari and Moa districts in eastern Cuba large areas are underlain by a common igneous rock that contains only between 5 and 10 per cent of iron, far too small a percentage to be profitably worked This iron is mainly in chemical combination with silica and alumina Surface waters and the gases of the air have, however, waged a constant attack upon this rock and in the course of long periods of years in this semi-tropical climate they have eventually produced about 15 feet of an incoherent soil that now contains around 50 per cent of iron no longer combined with silica and alumina but with oxygen and water and constituting a valuable iron ore that has been shipped to Baltimore for smelting The valueless components of the original rock were in the main carried away in solution, but the difficultly soluble iron oxides remained as a residuum to form what is known as a "residual" ore While residual ores are one of the subordinate varieties of iron ores, essentially all the ores of the important metal aluminum are residual. It follows from their mode of formation that residual ore deposits are apt to be thin but their lateral extent may be considerable

Seldom if ever does it happen that all of the valuable metal or its compounds concentrated as a residuum during the soil-making or "weathering" process remains in its original locality Some is almost certain to be carried downhill by the run-off of surface waters and be deposited some distance away, usually in admixture with materials from other sources In this way were formed the "placer" deposits that in past years have been one of the world's great sources of gold and that to-day yield a large fraction of the world's platinum and most of the world's tin The formation of most placer deposits involves, however, more than the mere movement of the residuum of rock decay to a new locality; it involves a further concentration of the valuable component during this transport In the case of gold, platinum and tin deposits these are the heaviest components and offer more resistance to transportation in streams than the lighter components. In the placers of Colombia in South America gold and platinum, each from different sources, are now mingled in the same gravels Since placers are sediments they constitute one variety of sedimentary ore deposit

In the degradation of the land surface, compounds of the valuable metals contained in the common rocks or in ores exposed to weathering are not always resistant to the solvent action of surface waters but may be partly or completely dissolved Once in solution the metals may be transported with facility for distances measured in a few feet or in many miles Iron in some of its combinations, such as the carbonates, is readily taken into solution in the soils and may be transported laterally for long distances to some lake or an arm of the ocean there to be reprecipitated as a sediment rich enough in iron to constitute an ore The largest iron ore deposits of England, the famous Cleveland ores, are iron carbonate beds originating in such a manner Such deposits constitute still another type of sedimentary ores

Iron carried to the sea either in true solution or in very fine mechanical suspension (colloidal) may also be reprecipitated as the oxide hematite, and some of the largest of the world's iron ore deposits, such as those of Lorraine in France, of Newfoundland and of Birmingham, Alabama, were formed in this way Their sedimentary origin is amply attested by the presence in the ore of features such as bedding, cross-bedding and fossil remains of marine origin, features common in the more ordinary kinds of marine sediments The precise means by which the iron oxides were

deposited on the floors of the ancient oceans is still far from clear, largely because deposits of this sort for some unexplained reason are not forming in the seas to-day.

Before concluding our consideration of the ore deposits that owe their formation to the processes of gradation, mention must be made of some in the formation of which more than one gradational process has been involved In the development of the greatest of the iron ore deposits of the United States, those of the Lake Superior region, there was involved first the deposition of iron-rich sediments in an ancient ocean, then at a much later period when these sediments had become part of the land surface their iron content was in places approximately doubled by the leaching out of components other than iron, that is by residual concentration

Furthermore, gradational processes of concentration are often superimposed upon the processes of concentration related to vulcanism which are next to be described Thus, for example, many of the great copper deposits formed in the first instance by solutions rising from volcanic sources have later been notably changed when exposed at the surface and subjected to oxidation by air and to the solvent action of surface waters Copper has been dissolved from the portions of the deposits nearest the surface, carried downward in solution, and redeposited deeper down within the ore body To this process, which is known as "downward enrichment," many of the world's copper deposits owe their extraordinary richness Others owe their workability to this process which raised their tenor from below to above a workable grade The largest of the copper mines of the United States, that of the Utah Copper Company of Bingham Canyon, is an instance of this sort

Thus it becomes evident that the familiar agencies that are operative to-day in sculpturing the landscape—air, the surface streams, to a lesser degree underground waters, the lakes and the oceans—have been responsible in the past for the formation of many of the world's ore deposits, among them some of the largest and richest.

Ore Deposits Related to Vulcanism

There remains, however, a great group of ore deposits, including most of the ores of copper, lead and zinc, silver, tin and mercury and the gold ores other than placers, about whose origin many uncertainties have existed The mineral veins, those sheet-like or tabular ore deposits following fractures in the common rocks, are the commonest, though not the only, form of deposit belonging to this group One reason for uncertainty concerning their origin is not far to seek and is implied by the simple fact that no one has ever seen a metalliferous vein in process of formation The conclusion to be drawn from this is not that mining geologists have been particularly unobservant but rather that the processes of metalliferous vein formation take place exclusively far below the surface where they are effectively screened from all possible human observation Only long after, often millions of years after, these veins were formed are they finally exposed to our eyes and brought within range of mining operation by the slow wearing down of the surface by the process of degradation The metalliferous veins are therefore presented to our view fully formed and whatever we learn of the processes by which they were brought into being must be a matter of inference rather than direct observation Such handicaps serve rather to intrigue the geologist than to discourage him, and logical inference on the basis of careful observation may be a powerful weapon for discovery of the truth Let us marshall briefly some of the observations and

inferences that have cleared away many though not all of the mysteries that have surrounded these ore deposits

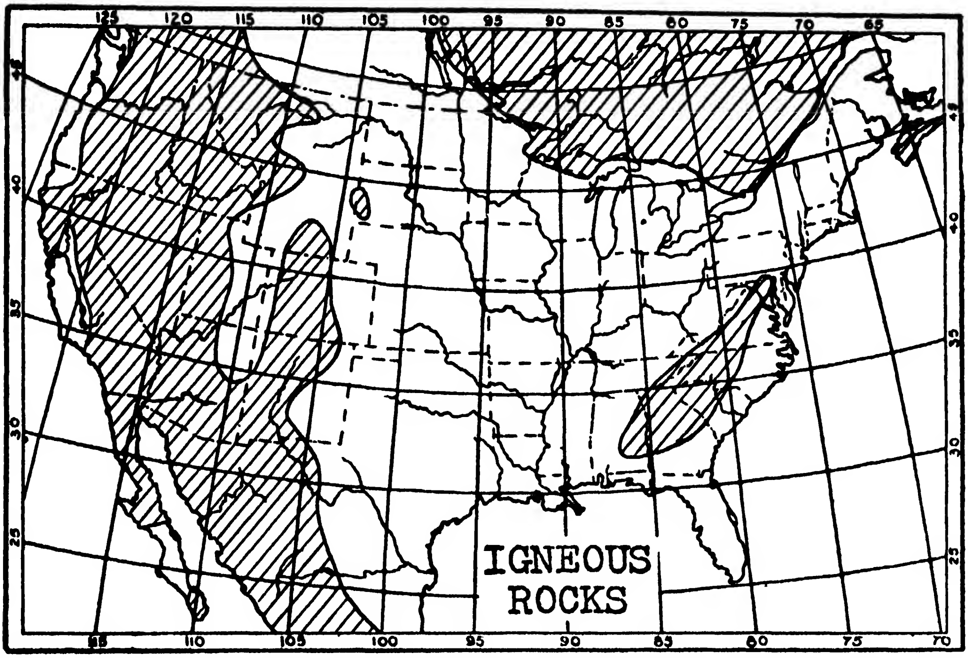
Excluding for the moment all those ore deposits that can be shown to have developed by the processes of gradation and centering our attention on other types, several broad relationships are of particular significance First and foremost is the fact that regions characterized by ores of these sorts are also in general characterized by an abundance of igneous rocks In short, there is a geographic parallelism between the distribution of ores and of igneous rocks This parallelism is strikingly brought out for North America in the accompanying chart The relationship is too general a one to be fortuitous There is, moreover, a second broad relation that is almost equally significant, namely that the periods in the geologic past that were periods of ore deposition were also periods of igneous activity The combined import of these two relationships is that ore formation of the sort now under consideration is in some way related to igneous activity, that is, to vulcanism in the broadest meaning of that term

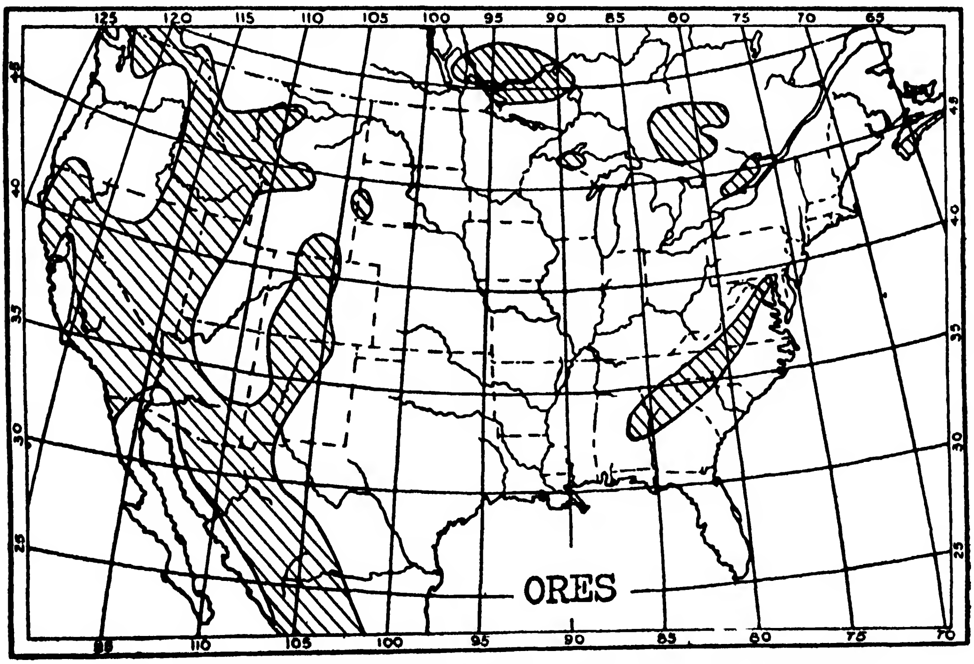
Vulcanism, however, is a process that is going on to-day at the surface of the earth, only locally to be sure, but often with a spectacular violence that has aroused not only the interest and awe of the layman, but inspired the searching investigation of the scientist as well The processes of vulcanism as displayed at the earth's surface are now known in a wealth of detail and are well understood Why then, if some ore deposition is a phase of vulcanism, is there any uncertainty concerning the ore-forming processes? The answer lies in the fact that ore deposition is not connected with those processes of vulcanism which are observable at the surface but with deep-seated vulcanism that can not be studied in action

The relations between igneous rocks and ore deposits if viewed on a more restricted scale often confirm in an interesting way the evidence from the broad relationships The tin, copper and other ores of the famous Cornwall district in Britain are closely associated with great bodies of granite whose coarse to medium textures show that they solidified a considerable distance below the surface Away from the granites mineralization disappears The great Braden copper mine in Chile and the famous gold deposits of Cripple Creek in Colorado are strictly localized in and around the "roots" of old volcanoes that have been laid bare by erosion Similar instances could be multiplied almost indefinitely

When consideration is narrowed to individual ore deposits additional evidences of a relation to igneous activity are revealed and a surprising variety is found not only in the metals involved but in the manner of their association with the igneous rocks Because of such differences in association several classes of ore deposits may be recognized, each related to vulcanism but each formed by a little different mechanism of natural concentration of the metals

In the first class are those ore deposits that are themselves igneous rocks and show clear evidence by the kinds of minerals they contain and the way in which they are intergrown of direct crystallization from molten rock material—or so-called "magma" Many of these deposits can be traced without break by complete transitions into common varieties of igneous rocks containing only small amounts of the metals It is evident that the processes of natural concentration responsible for these ores took place either before or during the crystallization of the rock from the molten state This is the process known to the geologist as "magmatic differentiation" The actuality of this process is amply demonstrated not only by the gradations of some ores into common igneous rocks but of various kinds of common igneous rocks





THE DISTRIBUTION OF IGNEOUS ROCKS AND ORE DEPOSITS

A COMPARISON OF THE DISTRIBUTION OF IGNEOUS ROCKS AND OF ORE DEPOSITS IN NORTH AMERICA. THOSE ORE DEPOSITS THAT ARE CLEARLY OF SEDIMENTARY ORIGIN HAVE BEEN OMITTED

into each other; it is indeed the process by which most igneous rocks have been formed Among the ore deposits that have been formed by magmatic differentiation are essentially all the chromium ores of the world, the important platinum ores of South Africa, and many of the world's nickel ores

Another great class of ore deposits, though not themselves igneous rocks, are almost always immediately in contact with igneous rocks and may thus be suspected of being related to them in genesis Usually the rock in which the ores occur is a limestone, and calcite, the principal mineral of limestone, is a common component of the ores. The contact between the igneous rock and the ore is commonly sharp and the igneous rock usually retains its ordinary composition up to the contact It is evident from such sharp contacts that the ore is not due to digestion of limestone by molten igneous material, nor would such a process offer any explanation of the high metal content of the contact zone. The mineral composition of that zone affords, however, a clue to what has actually occurred Although the limestone away from the igneous contact is commonly nearly pure calcium carbonate, the contact zone contains not only calcium carbonate but also calcium silicates in the form of a variety of minerals of which garnet is one of the commonest It is evident that silica has in some way been carried out of the igneous rock shortly after its intrusion and crystallization and has reacted with the calcium carbonate of the limestone to form calcium silicates. At the same time compounds of the metals, principally with sulfur, were introduced. The agents that accomplished this transfer were obviously solutions tenuous and mobile enough to penetrate the most minute pores of the limestone for long distances and probably hot enough to be gaseous. Ores of the preceding class showed us that magmas in many instances contained the metals in abundance; ores of the class we are now considering show that under some circumstances metals and other substances may be carried out of the crystallizing and cooling magma in solution and deposited in the immediately adjacent country rock, particularly if that rock happens to be an easily altered type such as limestone. This is not one of the most important classes of ore deposits, but it includes many fairly large copper and iron deposits, especially in the western United States

Limestones are not, however, the commonest types of wall-rocks that border intrusive igneous masses The wall-rocks may be shales, sandstones, schists, or older igneous rocks, all of them less capable of reacting vigorously with the mineralizing solutions than are limestones. What will be the fate of metal-bearing solutions entering such rocks? In the first place some chemical reaction between the solutions and these wall-rocks would be inevitable although less vigorous than with limestone In the second place these solutions would circulate most actively along fractures in the wall-rocks and in and near such fractures, while the solutions moved farther from their source and their temperature and pressure declined, their metal content would be deposited Along such fractures would be formed, therefore, the metalliferous veins flanked to various distances on either side by partly altered wall-rock

This modern concept of the formation of metalliferous veins finds interesting confirmation in certain mining districts in which there is a concentric or zonal distribution of veins of several varieties around igneous intrusions, those nearest the intrusion showing by the kinds of minerals they contain higher temperature conditions of formation than those farther removed. Contact deposits may and often do occur in the same district as metalliferous veins, as, for example, at Clifton and Morenci in Arizona An

igneous intrusion may, of course, be bordered in places by limestones but elsewhere by other types of rocks, or limestone next the contact may be succeeded by other rocks farther away and metals not deposited as contact deposits in the limestone may travel on to the outlying rocks there to be deposited as mineral veins

Inevitably there will be situations in which limestone occurs at a considerable distance from an igneous intrusion yet still within reach of the mineralizing solutions. Under such circumstances the mineralizing solutions deposit ores in the limestone but the reaction differs from that characteristic of "contact deposits" The silica of the metal-bearing solutions instead of combining with the lime of the limestones to form lime silicates is deposited in the limestone as silica in the form of quartz, the calcite of the limestone being at the same time dissolved This is a lower temperature type of reaction than that characteristic of the contact deposits

It is of interest to inquire what becomes of the mineralizing solutions after most of the metals which they carried have been deposited. In some instances such solutions, probably consisting principally of water, join the general body of ground water that fills the pores and crevices of the rocks for hundreds or even thousands of feet below the surface In other instances it probably issues at the surface as hot springs which are rather common in mining regions and which often carry the metals in considerable variety though never in commercial amounts Hot waters containing dissolved metals in small amounts are also encountered in the underground workings of a few mines developing ore deposits of comparatively recent origin, as at the famous Comstock lode in Nevada They probably represent the dilute modern counterpart of the solutions that at an earlier period deposited the ores

It is of interest to consider the number of metals that may be yielded in commercial amounts by a single mining district. Especially in the case of iron ores only a single metal may be recovered, but more commonly a variety of metals is obtained even when the mineralization seems to have come from a single type of igneous source such, for example, as granite. Thus at Butte, Montana, where igneous masses of granitic composition seem to have been the common source of all the ores, copper, lead, zinc, gold, silver, manganese and arsenic are commercially recovered Often, however, it is found that within such a district the relative proportions of the several metals varies with the distance from the supposed source of the mineralization Thus at Butte copper ores predominate nearer the source and lead, zinc and manganese somewhat farther removed

If, as most mining geologists have come to believe, many ores have been deposited by solutions coming from igneous rocks during or shortly after their crystallization, then we should expect to find certain types of ores characteristically associated with certain types of igneous rocks In many instances this is in fact the case. Thus the ores of platinum and of chromium are invariably associated with the dark-colored igneous rocks, the so-called "basic" rocks. In contrast to this the ores of tin are almost invariably associated with granites Encouraged by such relationships it has been the ambition of economic geologists to definitely relate all the varied ore types to various types of igneous rocks Thus far, however, these efforts have met with very partial success for several reasons In the first place certain metals such as copper and iron may be associated in origin either with highly siliceous, basic or intermediate rocks Nickel may be associated in origin either with highly siliceous rocks such as granites or with basic rocks such as gabbros. In the second

place a single mining district is often characterized by a great variety of ores as well as igneous rocks, and the task of relating particular ores to particular igneous types is a most uncertain one In the third place the solutions given off by a single type of igneous magma may deposit progressively different types of ores as they travel farther away from the igneous source

The problem of the temperatures at which the ores related to vulcanism have been formed has always been of interest to economic geologists The highest temperatures would of course be expected in those ores that are direct crystallizations from the magmas and several lines of evidence, including direct measurements of the temperatures of lavas at volcanoes, indicate that temperatures of 600 to 1,300 degrees Centigrade may have characterized such deposits at the time of their formation For the contact deposits developed not in the intrusion but in the immediately adjacent wall-rock indirect evidences indicate temperatures of from 500 to 800 degrees From such relatively high levels the temperatures decline with increasing distance from the igneous source until for some of the more remote ore deposits the temperatures of formation were probably between 100 and 200 degrees Centigrade Laboratory determinations of the temperature ranges at which some of the characteristic minerals of ores are stable have been of great aid in inferring the temperatures of formation of ore deposits though subject to some corrections for pressure and other factors

The chemical and physical constitution of the solutions from which the ores related to vulcanism have been deposited is a matter on which there has been wide diversity of opinion and upon which geologists have only begun to accumulate sound knowledge The magmas from which those ores that are igneous rocks crystallized were highly concentrated and extremely hot solutions, rather closely analogous to the slags formed artificially in our blast furnaces. Even these solutions carried highly volatile components, as is amply evidenced by the steam and other less abundant gases given off at active volcanoes. A few geologists have concluded that the metalliferous veins were also deposited from solutions of high concentration differing from magmas mainly in their greater metal content and have used the term "ore magmas" Most geologists, however, draw a very definite distinction between magmas and the solutions that have been given off by magmas and are responsible for the deposition of ores in the bordering rocks, although admitting that transition types may exist They are impressed with the prevailingly sharp contacts between the igneous rocks and their wall-rocks which indicate that the magmas have not penetrated the minute pores of their walls They are equally impressed on the other hand with the evidence present in nearly all mining districts that the ore-depositing solutions have penetrated the rocks in an astonishingly intimate manner, occupying not only minute pores but penetrating where the highest powers of the microscope reveal no pores This can only mean that the mineralizing solutions were exceedingly mobile solutions, much more mobile than the magmas even at lower temperatures and pressures They were also capable of dissolving large amounts of mineral matter from the rocks they so intimately penetrated while at the same time depositing other minerals in the place of those dissolved None of the components of the ores themselves as we find them to-day can explain such mobility Fusion of the ores as in an open hearth furnace does not produce a highly tenuous liquid capable of intimately penetrating rock pores for long distances It seems necessary to conclude that the mineralizing solutions owed their mobility to some component that was not deposited with the ores and has since disap-

peared, leaving no direct trace of its former presence. As the reader has already surmised, this component was probably water, first in the gaseous and later in the liquid state There is ample evidence that water is a minor but omnipresent component of magmas In the first place steam is by far the most abundant of the many gases given off by magmas at active volcanoes Secondly, water is an essential component of some of the common minerals of igneous rocks, such as the micas and hornblende, and it must therefore have been present in the magmas from which these minerals crystallized In the third place the analysis of gases obtained from crushing fresh igneous rocks *in vacuo* shows that water constitutes 70 to 97 per cent of the total gases collected Measured in per cent of the weight of the entire rock, the amount of water revealed by analyses of the freshest igneous rocks obtainable is small, usually a few tenths of one per cent. In terms of volume, however, the percentage of water reckoned as liquid would be 2½ to 4 times as great and reckoned in the state in which it must have left the magma—namely as gas—its volume would be many times, indeed tens of times, that of the rock from which the gases were derived, the exact amount depending of course upon the temperature and pressure of the gas There would seem to be little doubt therefore of the competence of cooling and crystallizing masses of magma to give off gases —chiefly gaseous water—in sufficient abundance to transport the metals in large amounts and to form ore deposits If lingering doubts remained they might be dispelled by the high probability, demonstrated by recent work at the Carnegie Geophysical Laboratory, that magmas in the earlier stages of cooling may increase their original water content by absorption from the wall-rocks only to expel it again as cooling progresses further and crystallization goes on.

As to the precise manner in which the components of the ores were transported by the highly aqueous solutions, very little is as yet known It is easy to understand how some of the common components of ores, such as calcite, may be dissolved in aqueous solutions carrying carbon dioxide gas and precipitated when this gas escapes Quartz, another common mineral in ores, though difficultly soluble in water at ordinary temperatures is greatly more soluble at elevated temperatures Many of the metallic components of ores, such as gold, platinum, the oxides of tin and iron and many others, are practically insoluble in pure water even at elevated temperatures Some special mechanism is necessary for their abundant solution and transport in mineralizing solutions The problems involved are too varied and intricate to be discussed in a non-technical article, but two general considerations must be kept in mind in any attempts to solve them In the first place, some of the components of the ores may be transported in those exceedingly fine mechanical suspensions commonly termed "colloidal solutions" rather than in true solution Among the ores of the type related to vulcanism there are many whose unusual agate-like textures indicate deposition from colloidal suspension While colloidal deposition is less common than deposition from true solutions, its possibility should be kept constantly in mind In the second place, even when considering transport in and deposition from true solutions it should be remembered that some of the familiar elements present in our ores may at high temperatures enter into unfamiliar combinations It has been suggested that such compounds as SiH_4, SiF_4 and H_2SiF_6, as well as compounds of silicon and sulfur, may be important components at high temperatures of the solutions given off by crystallizing magmas

CHARLES DARWIN AND CHILD DEVELOPMENT

By ARNOLD GESELL, M.D.

PROFESSOR OF CHILD HYGIENE AND DIRECTOR OF CLINIC OF CHILD DEVELOPMENT, YALE UNIVERSITY

"WITHOUT doubt the first three!" This was the emphatic answer which Charles Darwin gave when as an old man he was asked which years of life he considered the most "subject to incubative impressions" There is much evidence that he was deeply intrigued by the phenomena of human infancy.

Darwin's mind ranged over all natural phenomena—geology, botany, zoology, anthropology The same passionate inquisitiveness as to the genesis of things which caused him to spend years of exacting study on his "beloved barnacles" led him also to set down abundant notes on the behavior of his babies He was the father of ten—six sons and four daughters, born within a period of seventeen years. The tenderness and sympathetic insight which he displayed as a parent are well known Less recognized is the significance of his work in the scientific study of child development.

Human infancy is full of enigma. Grave perplexities arose in the minds of pre-Darwinian theologians who tried to explain the imperfection, or as they called it, "the pettishness" of childhood The problem of crying troubled the discussions of hereditary guilt Saint Augustine insisted that the crying of a baby is *not* sinful, and therefore does not deserve eternal damnation We shall see, presently, how Darwin approached this ancient riddle of the infant's cry.

Darwin's perplexities were those of a naturalist His mind had a scientist's "naked need for ideological order." This order he tirelessly sought.

My first notebook (on the transmutation of species) was opened in July 1837 I worked on true Baconian principles and without any theory collected facts on a wholesale scale. . In October 1838, that is fifteen months after I had begun my systematic enquiry, I happened to read for amusement Malthus on Population. . . . My first child was born on December 27, 1839, and I at once commenced to make notes on the first dawn of the various experiences which he exhibited, for I felt convinced, even at this early period, that the most complex and fine shades of expression must all have had a gradual and natural origin.

From the foregoing dates it is clear that the study of infant behavior very early contributed to the formation of Darwin's ideas He converted the enigma of infancy into one more touchstone for understanding the origin of species. Much as he admired Sir Charles Bell's writings, he could not believe, with Bell, that man had been created with certain muscles specially adapted for the expression of feelings.

And so Darwin began a series of observations and even a few benign experiments on his newborn son, "Doddy"

On the seventh day I touched the naked sole of his foot with a bit of paper, and he jerked it away, curling at the same time his toes, like a much older child when tickled. The perfection of these reflex movements shows that the extreme imperfection of the voluntary ones is not due to the state of the muscles or of the coordinating centers, but to that of the seat of the will. . . .

When this child was about four months old, I made in his presence many odd noises and strange grimaces, and tried to look savage; but the noises, if not too loud, as well as the grimaces, were all taken as good jokes; and I attributed this at the time to their being preceded or accompanied by smiles. When five months old, he seemed to understand a compassionate expression and tone of voice.

The recorded observations of Darwin's infant covered a wide range of subjects such as vision, winking, hearing, anger, fear, pleasurable sensations, affection, association of ideas, reason, left-handedness, moral sense, unconsciousness, shyness,

language, sympathy. Thirty-seven years later (1877) the diary records reappeared as "A Biographic Sketch of an Infant," published in *Mind*, the British Quarterly Review of Psychology and Philosophy The manuscript was submitted to the editor with characteristic self-deprecation: "I cannot judge whether it is worth publishing, from having been so much interested in watching the dawn of the several faculties in my own infant "[1] Darwin was remembering the "fine degree of paternal fervour" which had prompted him as a young father and scientist to declare, "I had not the smallest conception there was so much in a five-month baby "

Darwin's observations of infants were by no means limited to his first-born He renewed his observations on Doddy's brothers and sisters, concentrating on the characteristics of instinctive and emotional behavior The most valuable and systematic data were incorporated in his famous essay on "The Expression of the Emotions in Man and Animals" (1872). Darwin had first intended to treat the subject in a single chapter of his "Descent of Man," but the essay inevitably expanded into a book—a book which a theological reviewer immediately described as "the most powerful and insidious of all the author's works."

This volume exhibited in an eminent degree, as his friend A R Wallace remarked, the author's restless curiosity and an insatiable longing to discover underlying causes Darwin left no stone unturned in his search for data He carried on a heavy correspondence, circulating printed inquiries among physiologists, physicians and missionaries, on items such as follow. (11) Is extreme fear expressed in the same general manner as with Europeans? (4) Do the children when sulky, pout or greatly protrude the lips? (16) Is the head nodded vertically in affirmation, and shaken laterally in negation?

Nothing better illustrates Darwin's method of investigation and his outlook on the phenomena of child development than his studies of the age-old problem of infant crying He observed frowning, pouting, screaming, tears, weeping in his own children He plied his friends to make similar observations In a letter to Huxley he asks Mrs Huxley "to look out when one of her children is struggling and just going to burst out crying " And he adds, "A dear young lady near here plagued a very young child for my sake, till he cried, and I saw the eyebrows for a second or two beautifully oblique, just before the torrent of tears began . . "

Far from being a trivial incidental, the obliquing of the eyebrows and the contraction of the muscles around the eyes became a topic of persistent research. He analyzed Duchenne's photographic records of the facial muscles under galvanic stimulation He consulted paintings and sculptures He gathered data from asylums for the insane. He enlisted keepers of the zoo and he also closely watched his own cats and dogs From London and Hamburg he secured photographs of crying children, many made expressly for him (He remarks, "I found photographs made by the instantaneous process the best means of observation, as allowing more deliberation." How he would have delighted in the delineations of cinema records had they been available to him!)

Probing deeper into the physiology of the weeping eye he enlisted the help of Professor Donders, of Utrecht, who carried through an elaborate experimental

[1] Darwin added that he would never have thought of sending the manuscript had not an article by M Taine appeared in translation in an earlier issue of *Mind*. When Taine contributed the original article, "The Acquisition of Language by Children," to the *Revue Philosophique* (January, 1876) he commented that his observations had been interrupted by the calamities of the year 1870—calamities that are now repeating themselves, less than 70 years later.

study on the action of the eyelids in the determination of blood flow from expiratory effort Even after the publication of the volume on "Expression of the Emotions," Darwin kept in touch with Donders, pursuing still further the problem of orbicular contraction. "I think," he writes, "it would be worth while to ascertain whether those born blind, when young, and whilst screaming violently contract the muscles round the eyes like ordinary infants. And, secondly, whether in after years they rarely or never frown " Always alert to alternative possibilities, he continued with characteristic avidity for facts, "If it should prove true that infants born blind do not contract their orbicular muscles whilst screaming (though I can hardly believe it) it would be interesting to know whether they shed tears as copiously as other children "

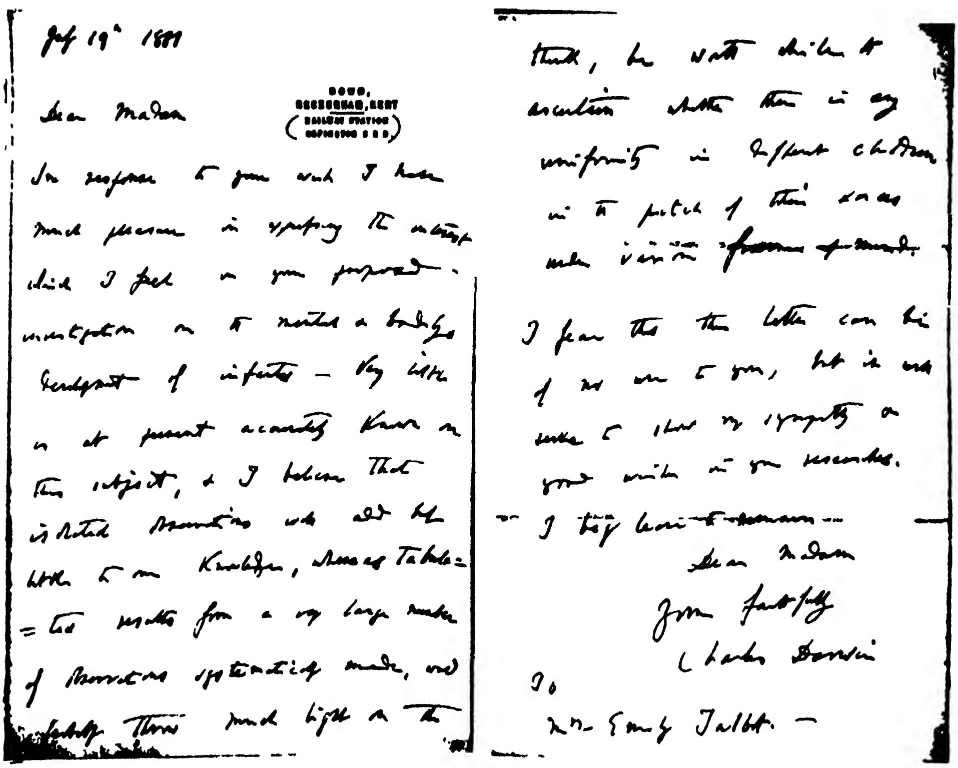
It was not Darwin's habit to terminate his investigations Soon after publication he began to revise his volume on "Expression " His cousin, Galton, called attention to an omission "Was it not universal among blubbering children (when not trying to see if harm or help was coming out of the corner of one eye) of pressing the knuckles against the eyeballs, thereby reinforcing the orbicularis?" Almost apologetically, Darwin says he should have thought of this point "As far as my memory serves, they do not do so whilst roaring, in which case compression would be of use I think it is at the close of the crying fit, as if they wished to stop their eyes crying, or possibly to relieve the irritation from salt tears I wish I knew more about knuckles and crying "

Darwin's approach to the problem of child behavior is comparative He is equally interested in the pouting of the European child, of Kafir, Fingo, Malay, Abyssinian, orang and chimpanzee He finds that discontented primates protrude their lips to an extraordinary degree, Europeans to a lesser degree, but that among young children lip protrusion is characteristic of sulkiness throughout the greater part of the world He felt certain that our progenitors protruded their lips when sulky and disappointed. Indeed, the study of emotional expression strengthened the conclusion that man is derived from some lower animal form.

Comparative psychology to-day has taken on a limited connotation which makes it almost synonymous with animal psychology For Darwin, the naturalist, comparative psychology was more capacious, it was truly comparative. He was primarily interested in phyletic implications, and the breadth of Romanes' work in this field appealed to him In a letter (to Romanes, 1878) he compared half playfully, half seriously, the intellect of a young monkey and that of his two-year-old grandchild (Frank's son). He saw in the thinking of deaf-mutes "one of the richest of all mines, worth working carefully for years, and very deeply " Again, half seriously, half humorously, he relayed a significant suggestion to Romanes "Frank says you ought to keep an idiot, a deaf-mute, a monkey, and a baby in your house!"

Darwin was not a psychologist, but he had already inaugurated concepts of life and growth which were to revolutionize the psychological formulations of child development He profoundly influenced G Stanley Hall, a young scientist who became a powerful exponent of Darwinism in America With fertile suggestiveness and comprehensiveness, Hall applied the concepts of evolution to the mind of the child and of the race Hall also became the father of a nation-wide child study movement which liberalized elementary education and led to scientific advances in the study of child development

This movement in its mixture of empirical fact-finding and zeal for social welfare was characteristically American.



PAGE ONE AND PAGE EIGHT OF A LETTER WRITTEN BY CHARLES DARWIN TO MRS EMILY TALBOT, SECRETARY OF THE EDUCATION DEPARTMENT OF THE AMERICAN SOCIAL SCIENCE ASSOCIATION

It began to take definite shape in the early eighties Vast areas of prejudice and ignorance had to be overcome, but this did not dampen the ardor of the pioneers who, as we shall see, called upon Darwin for help, the year before he died at Down

The American Social Science Association had just been founded In 1881, Mrs Emily Talbot, enterprising secretary of its education department, issued a circular in which she referred to the new investigative spirit of the time,

> . . the intelligence of animals, even coming in for a due share of attention . . Recently, some educators in this country have been thinking that to study the natural development of a single child is worth more than a Noah's Ark full of animals. . . In this belief the Education Department of the American Social Science Association has issued the accompanying Register, and asks the parents of very young children to interest themselves in the subject—
>
> 1. By recognizing the importance of the study of the youngest infants 2 By observing the simplest manifestations of their life and movements 3 By answering fully and carefully the questions asked in the Register 4 By a careful record of the signs of development during the coming year, each observation to be verified if possible by other members of the family 5 By interesting their friends in the subject and forwarding the results to the Secretary 6 Above all, by perseverance and exactness in recording these observations
>
> From the records of many thousand observers in the next few years it is believed that important facts will be gathered of great value to the educator and to the psychologist

This ambitious program did not, however, fail to awaken some resistance and satire Noah's Ark was still far from a metaphor to large sections of the population who fumed or laughed at Charles Darwin, author, in 1859, of that shocking, green-covered volume entitled, "The Origin of Species" As late as 1889, a lecture on "The Scientific Study of Infant Intelligence" proved a popular suc-

cess by reason of the fun it poked at the new child study (The lecture was given in "The Mechanics Course" of the Sheffield Scientific School of Yale University, and some months later before the Scientific Society of Bridgeport, Connecticut, by Henry T Blake)

With devastating good nature, the lecturer cited the assiduous experiments of Professor Preyer, Monsieur Perez, Herr Kussmaul and Dr. Darwin, with repeated ironic reference to the doctor's family pride in his simian tree-dwelling forefathers Referring to the registers of the American Social Science Association, the lecturer concluded:

> The registers will go like *la grippe* into every house. Mothers, sisters, aunts, grandfathers, of course, possibly even fathers, will engage in the scientific study of infant intelligence, and the merits of the newly born generation will be rolled into the fold of a permanent record with as much precision and certainty as we used to operate last year's puzzle of "The-little-pigs-in-clover." Every properly constituted University and every Scientific Association will have its cradle of science and its baby chair of philosophy Under the stimulus of registration also, a vast improvement may be hoped for in the quality of the registered article

This ridicule was entertaining, and not always amiss But to-day the ironic prophecy has a new irony—it has come true Every well-constituted university in America now has a chair or courses in child psychology, and a nursery school for preschool children has almost become a standard feature of the academic campus

Charles Darwin took the American Social Science Association Register of Infant Development more seriously than our popular lecturer With a courtesy which was typical of him, he addressed a lengthy letter to Secretary Emily Talbot. This letter is so revealing that it is here reproduced in full [2]

[2] The original eight page letter in Darwin's own hand is now in the possession of Professor Marion Talbot, daughter of Mrs Emily Talbot, who kindly provided us with a photostatic reproduction.

July 19" 1881

DOWN
BECKENHAM, KENT
RAILWAY STATION
ORPINGTON, S.E.R.

DEAR MADAM

In response to your wish I have much pleasure in expressing the interest which I feel in your proposed investigation on the mental & bodily development of infants —Very little is at present accurately known on this subject, & I believe that isolated observations will add but little to our knowledge, whereas tabulated results from a very large number of observations systematically made, would perhaps throw much light on the sequence & period of development of the several faculties This knowledge would probably give a foundation for some improvement in our education of young children, & would show us whether the same system ought to be followed in all cases

I will venture to specify a few points of enquiry which, as it seems to me, possess some scientific interest For instance does the education of the parents influence the mental powers of their children at any age, either at a very early or somewhat more advanced stage? This could perhaps be learnt by school masters or mistresses, if a large number of children were first classed according to age & their mental attainments, & afterwards in accordance with the education of their parents, as far as this could be discovered As observation is one of the earliest faculties developed in young children, & as their power would probably be exercised in an equal degree by the children of educated & uneducated persons, it seems improbable that any transmitted effect from education would be displayed only at a somewhat advanced age. It would be desirable to test statistically in a similar manner the truth of the often repeated statement that colored children at first learn as quickly as white children, but that they afterwards fall off in progress. If it could be proved that education acts not only on the individual, but by transmission on the race, this would be a great encouragement to all working on this all-important subject

It is well known that children sometimes exhibit at a very early age strong special tastes, for which no cause can be assigned, although occasionally they may be accounted for by reversion to the taste or occupation of some progenitor, & it would be interesting to learn how far such early tastes are persistent & influence the future career of the individual. In some instances such tastes die away without apparently leaving any after effect, but it would be advisable to know how far this is commonly the case; as we should then know whether it were impor-

tant to direct, as far as this is possible, the early tastes of our children. It may be more beneficial that a child should follow energetically some pursuit, of however trying a nature, and thus acquire perseverance, than that he should be turned from it, because of no future advantage to him

I will mention one other such point of enquiry in relation to very young children, which may possibly prove important with respect to the origin of language, but it could be investigated only by persons possessing an accurate musical ear. Children even before they can articulate express some of their feelings & desires by noises uttered in different notes For instance they make an interrogative noise, & others of assent and dissent in different tones, & it would, I think, be worth while to ascertain whether there is any uniformity in different children in the pitch of their voices under various frames of mind

I fear that this letter can be of no use to you, but it will serve to show my sympathy & good wishes in your researches

I beg leave to remain

Dear Madam
Yours faithfully
CHARLES DARWIN

TO MRS EMILY TALBOT —

The most concrete contribution which Darwin made to the embryonic science of child psychology was embodied in his volume on "Expression of Emotions" Here he deployed his genius as a naturalist with the same penetration which he brought to bear on barnacles, coral atolls, orchids and earthworms He did not set himself up as a psychologist, indeed he never entirely escaped a certain naive dualism in his views of the human mind But it was as a naturalist that he addressed himself to the far-reaching problems of fear, rage and affection He attacked them with a boldness, objectivity and freshness which make much present-day discussion of similar subjects seem somewhat anemic in comparison We may well go back to Darwin for vitalization of outlook and even of method For the scientific study of child development is in need of the naturalist's breadth of vision

The present year marks a significant anniversary It was exactly one hundred years ago that Darwin first clearly conceived his epoch-making theory. His chief contribution to the intellectual thought of his time lay in his perception of the gradual genesis of all living things, including the genesis of the human mind. The developmental outlook upon nature and upon its vast web of organic life led to profound revisions in the interpretation of childhood The concept of evolution with all its corollaries introduced a new and humanizing kind of relativity Even New England divines, still wrestling with Calvinistic and Augustinian ideas of original sin, softened their doctrines of infant baptism The new naturalism proved to be a solvent of the gloomier beliefs of fixity and fate So pervading was Darwin's influence that it has been said that he won for man absolute freedom in the study of the laws of nature

Without that freedom it would be impossible to penetrate into the meaning of human infancy and into the nature of child development. The modern scientific study of child development is in itself a social assertion of a free spirit of truth If that spirit is trammeled in any way, man will never know himself, because to know himself he must understand clearly the processes by which he came to be, the processes of child development So we can scarcely err in paying tribute to Charles Darwin, remover of trammels, even though we realize that science in its most organic sense is a social phenomenon, a cultural product. Darwin, more than any other single individual, initiated the genetic rationalism which now characterizes the investigation of human infancy.

LIFE AND HABITS OF BUMBLEBEES

By Dr. T. D. A. COCKERELL

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There are thousands of kinds of wild bees in North America, few of them known to any but specialists, and many of them still unknown to the specialists, still awaiting discovery and description Among all these, the bumblebees are few in species, usually perhaps about a dozen kinds in any one limited region, but they are so large, so common and so frequently beautifully colored, that one must be stupid indeed not to have noticed them The ancient Greeks had a word βομβος, or βομβυλιος, which was apparently used for the bumblebee, though very likely for other bees as well The first of these words becomes in Latin *Bombus,* which is the scientific name of the bumblebees to-day The second, latinized to *Bombylius,* has been applied to those fuzzy hovering flies, which in the grub state are often parasitic in nests of wild bees The two modern, semi-popular books on bumblebees are those of F W L Sladen and Otto Emil Plath The reader will at once notice that Sladen's book, published in England (1912), is called "The Humble-Bee" That of Plath, published in the United States (1934), is "Bumblebees and Their Ways" Humble or bumble, which is it to be? If we go back to the Greeks, or to the scientific designation, it is evidently Bumble But the Germans write Hummel, and the Oxford Dictionary quotes a passage dating from 1450, referring to "the grashop and the humbylbee in the medow" Shakespeare also wrote it humble bee (Midsummer Night's Dream) The two names were evidently contemporaneous, for we find bombyll bee in 1530, and bumble bee in 1681

There are many reasons why bumblebees should attract attention. They are not only objects of beauty, but they illustrate certain principles of biology in a striking manner We often think of life as a struggle for existence between individuals and species, but the principle of cooperation is continually developing among quite diverse groups It may be said to have begun when the most primitive one-celled creatures united to form many-celled animals and plants, with specialized cells and organs—a form of cooperation which made possible all the higher developments of life It took on another aspect when social organisms developed in the sea, of such a character that it is hard to say whether we have one animal or a colony of many Among the insects, we have the wonderful social communities of the bees, the ants and the termites, so closely resembling, in certain respects, human society Long before our species existed, these insects must have had their organized societies, which were then the highest expression of community life It is natural to ask, if the insects thus had a start on us by so many million years, how is it that they have not progressed to the human level? The answer must be, that they are governed by instinct, and for that reason, socialists though they may be, are exceedingly conservative They continue in the same way, age after age, with little change Man, having in a far greater degree the direction of his own affairs by voluntary efforts, is able to progress, but, alas! by the same token able to make mistakes

What intelligent person can avoid some curiosity to know how all these things came about? We can not live through the ages, and personally witness the drama of evolution, but we can compare different stages of the process which are still available to us If we are dealing with objects of art, we can arrange those of different periods, so that it is possible to see the developments from

century to century. In the case of insects, we have indeed some assistance from the fossils, but still more from the numerous species still living, which have become fixed, as it were, at different levels of development. Among the bees, we can arrange series showing the development of the tongue, the wings and other organs. Now the bumblebee, with its long tongue, is an advanced form, yet in its social organization it is much more simple than the honey-bee; it supplies us with a picture of a relatively primitive bee-society, throwing light on the origin of such societies. It is not, however, in the line of ancestry of the honey-bee, though distantly related. The two groups have many differences in structure, and must be regarded as different branches of the same trunk.

Another biological tendency illustrated by the bumblebee group is that of parasitism. There is in nature (even in human nature) a tendency to live at the expense of others. Sladen describes a case in which a nest of *Bombus lucorum* was invaded by a queen of *B. terrestris,* which killed the *B. lucorum* queen and was getting the *B. lucorum* workers to rear her young. This seems to illustrate the beginning of a process which, during the long ages, has led to the evolution of a distinct genus, called *Psithyrus,* the members of which similarly establish themselves in *Bombus* nests, and are in fact quite unable to live independently. There are very many groups of parasitic insects, which must have arisen independently. There are several kinds of parasitic bees, in no way resembling *Psithyrus.* But *Psithyrus* looks so exactly like an ordinary bumblebee that at first sight there seems to be no difference. It is impossible to doubt that these parasitic bumblebees arose from working ancestors, and have now lost the power to provision their own nests. This is shown by the fact that the queens and workers of *Bombus* have a large shining space on the hind legs for the collection of pollen, whereas the *Psithyrus* has nothing of the kind, only a convex surface covered with hair. Sladen found six kinds of *Psithyrus* in Britain, each breeding in the nest of a special kind of bumblebee. Plath observed that in two cases, at least, an American species of *Psithyrus* had two different bumblebee hosts. In any case, however, the parasitism is not indiscriminate, and we find that there is commonly, but not always, a striking resemblance in color-pattern between the parasite and host. One wonders whether the different kinds of *Psithyrus* all came from the same ancestor, or developed independently from different groups of *Bombus;* and why there are not enough sorts of *Psithyrus* to go around, some species of *Bombus* being apparently without such parasites.

With regard to the color pattern, the true *Bombus* not only shows a good deal of variation, but also, in a very curious way, similar patterns in the same district, in bees which are structurally very distinct. Thus in central Asia there is a district where the bumblebees are prettily marked with white, and without careful study, quite different kinds could be confused together.

The bumblebees are especially found in the temperate regions of the northern hemisphere, but also on the mountains, and in South America, where the great Andean range runs north and south, they not only occur at very high altitudes in Peru, but extend to the extreme south, where we find a large species covered with orange hair. Far to the north, they are almost the only bees. Thus on the Pribilof Islands in Bering Sea there is apparently only one sort of bee, the *Bombus kincaidii,* though there are many kinds of flowers.

In New Zealand, there are no native bumblebees, and the red clover did not set seed, but bumblebees were introduced from Europe, and as soon as they became numerous, plenty of good seed was obtained. The native bees of New Zealand,

which are not numerous, are primitive forms with short tongues.

Much has been written concerning the value of bumblebees as pollinators of flowers, especially those with long tubes, such as the red clover and the larkspur.

In some cases, the bumblebee will make a hole in the side of the corolla, and so secure nectar, and perhaps pollen, without paying for it. I have seen a bumblebee slitting the spur of a blue-columbine, a flower normally visited by butterflies If all the bees took to these burglarious ways, the flowers would in many cases fail to set seed, and the result would be disastrous to all concerned

What we call "the balance of nature" keeps things going at a fairly even level for very long periods of time Even the parasites may be valuable to their hosts (as species, not as individuals), by preventing overpopulation. But it must not be forgotten that hundreds of thousands of species have failed and perished, leaving no trace or at best a fossil to show what they once were

Both Plath and Sladen describe contrivances for rearing and keeping bumblebees in captivity. Such methods make it possible to study the behavior of the insects in detail, and have brought out the fact that the species differ in their methods and their conduct, just as they do in structure, size and color Accordingly, there are two sorts of classifications, one based on structural characters, such as are used by all students of animals, and another depending on behavior, especially that shown in provisioning the nest Plath, dealing with the New England bumblebees, has recognized four groups based on habits and has provided rather alarming Greek names to designate them. European authors, in particular, have divided *Bombus* into very numerous subgenera (many of these sometimes treated as genera), but this elaborate classification seems to be of doubtful utility, at least in some respects.

In America, the first great monograph of our bumblebees was that of H. J. Franklin, "The Bombidae of the New World," Transactions of the American Entomological Society, 1912–1913. This is so large and seems so complete that one would suppose the treatment to be final, but another revision will in due course be published by T. H. Frison, of the University of Illinois, who has already issued several important preliminary papers. As Plath points out, the numerous species in the far western states deserve intensive study, and in fact we, of our generation, have many things to discover.

Although we have emphasized the dominance of instinct in the affairs of these insects, it must be admitted that ordinary memory and what we must call intelligence have a part In the spring, the queen hunts for a nesting site, and chooses a suitable one, often after a very long search This may be regarded as an instinctive reaction, but what are we to say of her behavior when, having found the right place, she goes about to fix the location in her memory? She flies around in widening circles, until she feels competent to find the place again after a visit to the flowers Mr and Mrs Peckham, of Milwaukee, noticed the same sort of thing in the case of certain wasps, and discovered that the individual wasps were not equally clever In a moving picture made under Frison's direction, the track of the bee is graphically shown by a moving line, so that we can follow the bee as if we were looking at it from above

Another example of apparent intelligence, no doubt combined with instinct, is that of the so-called trumpeters. As long ago as 1700, it was noticed that some of the bumblebees, at the entrance of the nest, rapidly vibrated their wings, making a quite audible sound. Some thought this was done for exercise, preparatory to flight, as may be seen among birds; some supposed it was to arouse the colony to work. However, as in the case of the honey-bee, it is for the purpose of venti-

lating the hive, as Plath was able to demonstrate. Colonies kept on the south side of a building showed trumpeting or drumming activities on warm days, soon after the rays of the sun reached the nests As soon as the sun receded from the nest-box (these were artificial nests) the operations ceased, and not a single bee engaged in trumpeting in the colonies on the north side of the house, away from the sun's rays

In temperate regions, at least, the bumblebee colonies do not last throughout the year, and in the far north their duration must be very brief. The females which have developed during the summer spend the winter in hidden places, frequently in the sod near the old nests They come out in the spring and find new nests for the summer Thus, early in the season, one will find the large so-called queens flying about, but no males or workers The nests, on being opened, are found to contain a number of tub-like structures, with food for the young, and larvae or grubs in various stages of development The queen provides pollen for her offspring, but also feeds them by regurgitation The larvae develop very fast, and Plath states that in about seven days after hatching they are ready to spin cocoons and transform into pupae, which of course do not need to be fed. If all is well, the workers begin to emerge about 22 days after the eggs are laid These are small, but the queen goes on laying, and the increasingly prosperous colony produces larger and larger workers. Eventually, queens and males are produced, sometimes in large numbers. At length, says Plath, "The old queen, if still present in the nest, has lost her former vigor and gradually becomes more feeble, until at last we find her dead or missing One by one the workers die off, and in a short time the nest is completely deserted The comb does not long remain intact, for the work of the scavengers has already begun, and the larvae of the wax moth, *Vitula,* and of the beetle *Antherophagus* soon consume the last contents of the nest which once contained a rich and populous colony " The young queens have left the nest and gone into hibernation

Otto Plath, now a professor at Boston University, lived when young in Central Europe, and was first interested in bumblebees by the discovery that they made delicious honey This led to crude efforts to domesticate the bees, and while so occupied he became interested in their habits, and decided that he would write a treatise on their life-history This boyhood ambition lay dormant for many years, but was eventually the germ from which developed the important and original work published a few years ago.

PHYSICIAN VS. APOTHECARY, 1669-1671

AN EPISODE IN AN AGE-LONG CONTROVERSY

By Dr. CHARLES F. MULLETT

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THE notion—if we may draw conclusions from popular and semi-popular volumes on medical history—that "physician" and "quack" were interchangeable terms in the pre-allergy era dies hard So insidious is this condescending outlook upon the past that even informed persons overlook the gradations in the "darkness" of earlier medicine Yet marked distinctions have always existed between healers, and warfare between the trained physician and the "empirick" has been a persistent feature of medical history. In the numerous "health" books of sixteenth and seventeenth century England, the issue constantly appeared; moreover, at times it passed from the incidental stage to that of a full-length controversy. This was the case in 1669–1671 when several physicians sought to remove the "frauds and abuses" of the existing dispensary structure Needless to say, apothecaries resented the attack and insisted upon their own peculiar value to society

The opening blast of the controversy, fired by Christopher Merrett, "Dr. in Physick," charged apothecaries with falsifying their medicines and augmenting the number as well as the prices of prescriptions [1] Merrett specifically denounced the administration of medicines contrary to the prescription, the loading of medicines with honey and other cheaper ingredients, and the use of decayed drugs times without number. In chronic diseases, because of such practices, he said that apothecaries often undid the work of physicians by continuing a given prescription to the patient's grave disadvantage in health and purse Furthermore, apothecaries often created diseases in men's fancies in order to decoy these victims into the use of physic, made thirty pills when a physician prescribed twenty, and carried medicine appointed for one person to another Even worse than these abuses, however, was the common practice of recommending and bringing to the patients unworthy physicians, who complied with the apothecaries' interests

To make the situation worse, said Merrett, such fraudulent practices damaged honest apothecaries who could not compete with the prices set by the dishonest "chymists" Thus, most of the preparations found in the shops were "sophisticated," for the censors, discouraged by the multitude of empirics swarming in every corner, had omitted their wonted searches. Moreover, when the patient was cured and the physician had ended his visits, the apothecary was not above insinuating either the danger of relapse or of another distemper, and accordingly repaired to the physician for a prescription to cure the imaginary disease By reason of these experiences and the cost of apothecaries, many persons, instead of calling a physician, immediately sought out some common quack or

[1] "A Short View of the Frauds, and Abuses Committed by Apothecaries; as well in relation to patients, as physicians and of the only remedy thereof by physicians making their own medicines" (London, 1669). Merrett (1614–95) received his M D in 1643 and became a fellow of the College of Physicians in 1651. Three years later he began to lecture before the college and thereafter was periodically elected a censor. In addition to the tracts summarized here he edited an herbal in 1666–67 and wrote on urines in 1682.

mountebank. As if these abuses were not enough, apothecaries had always sought the ruin of the College of Physicians, by attacking it in Parliament and traducing it elsewhere

From a purely therapeutic angle Merrett concluded that the great charges imposed by apothecaries and the nauseousness of their medicines explained why such long-standing and habitual diseases as falling-sickness, convulsions, "winds in the bowels" and gout seldom got relief Yet apothecaries always blamed the physicians, crying out that the latter were great cheats for not informing the world of their secrets But revelations would not be safe, the apothecaries' incapacity for practice being manifest by their lack of education To reform the existing state of affairs, Merrett particularly recommended that physicians mix their own medicines and fill their own prescriptions

Quite naturally, the charges made by Merrett would not lie unanswered, but before turning to the replies, we may consider additional attacks on apothecaries, attacks apparently stimulated by Merrett's onslaught Merrett himself reentered the lists in 1670, with a somewhat more comprehensive attack than that of the previous year[2] In this second pamphlet he promised to conduct his readers to a spot where they could observe the usual method of the "vulgar" physician's examination of his patients This consisted, he said, of three notions · first, that a patient's grievance was either a discernible evident disease or an inward pain, second, that it was one of the two endemic diseases, scurvy or consumption, third, that it was the pox This theory, Merrett thought, might be acquired with less industry than fourteen years' study at a university. On the other hand, however he might reproach the vulgar physician for executing his employment with so little ingenuity, he saw greater reason for condemning the "water-gazer," who by examining streams of urine pretended to gratify his patients' curiosity concerning the disease about to overtake them, for some of these medicoes thought to discover as much by the urinal as the astrologer by the globe.

Merrett then turned to uncover the errors which operated to benefit the clerk and the grave-maker. Bleeding was greatly abused by the "hackneys" and was even taken notice of by the vulgar physicians, although their experience told them that it was death in measles and smallpox. Those who knew better had a pleasant sensation on observing how the "hackneys" in the country vomited their patients with crocus, scoured them with jalap and drenched them with water-cresses and brook-lime, terming all diseases, except fevers and agues, the scurvy Finally, Merrett did not overlook the "groaping" doctors, who pretended great difficulty in discerning a disease when they could not grope about the patient's sides and belly He concluded by recalling that many physicians had lately deplored the dishonesty, stubbornness and incapacity of apothecaries

Consequent upon the furor excited by Merrett through his first attack on the frauds and abuses of the apothecaries, he made his third excursion into the controversy in 1670, especially emphasizing the patient's complete ignorance of the apothecary's medicines.[3] When an apothecary had practiced of his own

[2] "The Accomplisht Physician, the honest apothecary, and the skillful Chyrurgeon, detecting their necessary connexion, and dependance on each other. Withall discovery of the frauds of the quacking empirick, the prescribing surgeon, and the practicing apothecary" (London, 1670).

[3] "Self Conviction, or an enumeration of the absurdities, railings against the College, and Physicians in general, (but more especially, the writers against the apothecaries) non sence, irrational conclusions, falsities in matters of fact and in quotations concessions, etc of a nameless person And also, an answer to the rest of Lex Talionis" (London, 1670).

head and the physician was not called in until extremity of danger, what reason was there, he asked, that the physician should take upon himself the discredit of the patient's death, or why should he teach the apothecary to practice further by curing the patient himself? The tract itself largely was given over to a dialogue between A. (anonymous) and M (Merrett) A complained that physicians everywhere, out of malice, denounced the apothecaries and neglected their shops M rejoined by leaving it to the reader whether the cheats performed by the apothecaries did not sufficiently justify the physicians making their own medicines.

Among others who participated in the attack inaugurated by Merrett, none perhaps exceeded in eminence Edward Maynwaring, also "Dr in Physick," who declared that in primitive practice everything pertaining to the physicians' art had passed through their own hands they had examined drugs, had had a true knowledge of pharmacy and had been expert in medicines[4] "After that manner the Science of Physick improved." Later, physicians divided their business and devolved part of it upon other men, laying aside the most considerable part of their profession, the preparation and management of medicines. Maynwaring, himself, separated the work of physicians into two parts, theoretical and practical, arguing that they "must prepare medicines, be personally present and active therein," for the physician was a natural philosopher who improved his knowledge of nature by "various Mechanick experiments"

Maynwaring did admit, however, that a physician might depend upon the apothecary's skill in medicines as upon the surgeon's skill in anatomy; at the same time he believed it much more important that the physician look into his medicines than into the "chamber-pot or close-stool." A physician of ordinary parts "with extraordinary curious medicines" could perform more and greater cures and make fewer mistakes than the most knowing and learned theorist with ordinary medicines The physician, who was not well practiced and skilful in medicinal preparations, but collected his medicines out of books, had but an "empyrical" practice, even though he were very learned, well read and "a long practiser in Physick" The knowledge of an herbal or of books pertaining to animals and minerals by no means made a doctor expert in medicines A physician ought to be sufficiently acquainted with medicines to give a rational account of every ingredient In conclusion, Maynwaring offered a few concrete suggestions Of the drugs imported into England, he said, a fourth part was more fit for the dunghill than for the body of man, and he that took such drugs needed no other disease His own intention and aim was the improvement of pharmacy and the securing it from being profaned and abused. This could be attained by restoring the ancient reverend esteem of the professors of medicine for that branch of their profession and by excluding all mechanic and illegal trespassers.

Again in the same year, 1670, Maynwaring rode his favorite hobby of physicians making their own medicines.[5] In

[4] "The Ancient Practice of Physick, Revived and Confirmed as the only way for improvement of this science, security of the sick; and repute of the professors" (London, 1670) Maynwaring (1628–99?) took his M B. from Cambridge, his M D from Dublin, and began to practice in 1663. He condemned violent purgatives and indiscriminate bloodletting and believed smoking to be productive of such diseases as scurvy. During the plague of 1665 he had a good record Rather ironically, in view of his share in this controversy, his contemporaries regarded him as an "empirick." He wrote extensively.

[5] "The Pharmacopoeian Physician's Repository accomodated with elaborate medicinal arcana's appositely serving to the whole practice of physick exhibited as an exemplar, for imitation and incitation, to the industrious professors in this faculty" (London, 1670).

a second tract he listed medicines under the divisions of head and nerves, lungs, stomach, spleen, and liver, heart and vital spirits, reins and bladder, spine and loins, genital and spermatic parts, external parts, anti-venereal, anodyne and anti-scorbutic and radical. He gave no recipes, but instead supplied directions for the use of the medicines, occasions when required, and the like. Some clue to the contents can be gained from his comment on a certain medicine, "Quintessentia Aurea," for spermatic and genital parts It helped "to concoct the seed that is crude, thin and waterish; whereby it becomes more effectual for generation; and is assistant to such as want children by exilerating the seed, and endowing it with prolifick spirits." Likewise in dealing with anti-venereal medicines for the "Venereal Lues, called thê French disease," he described certain pills as proper for persons "afflicted with that malady, which is not always got by impure copulation, but sometimes by intimate approaches and society, with infected persons of that nature," an interesting appreciation of the infective character of syphilis [6]

Another "Doctor of Physick," Jonathan Goddard, leaped into the discussion at the same time.[7] He too bemoaned the separation of the preparation of medicaments from their application, and the accompanying indifference of physicians to the actual manufacture Physicians, he said, if they had put their minds to the task, might have done as expert a job as the apothecaries. Ideally, the separation had the advantage of releasing the physician from inferior employment, but this benefit was lost if apothecaries failed to keep within the limits of their trade and meddled with practice. Goddard also regretted the unreasonable and inequitable state of affairs whereby, when a trained physician had through his industry and ingenuity mastered the secrets of anatomy or had discovered a new medicine, upon his communication of it to an apothecary nothing beneficial would result The apothecary had betrayed his trust Furthermore, when the apothecary took it upon himself to practice, he gave the medicine to his patients and so gained a hundred times as large a fee as the physician, the latter curing the patient only once for the ordinary fee and simultaneously teaching the apothecary to do it ever after for innumerable rewards This condition must ultimately impoverish many physicians

According to Goddard, it were thus far better to teach the patients than the apothecaries, especially since no dishonor attached to any physician who employed

[6] In 1670 also, Maynwaring published "Vita Sana & Longa The Preservation of Health, and Prolongation of Life Proposed and proved In the due observance of remarkable precautions And daily practicable rules, relating to Body and Mind, compendiously abstracted from the Institutions and Law of Nature " He found that the brevity of man's life was due primarily to variety, excess in meat and drink, immoderate sleeping, living in unwholesome places, worrying, excessive use of purgatives, ill prepared medicines, and the like To regain primitive longevity, man should have fresh air, suitable clothing, a good climate and regular eating habits Maynwaring also supplied special rules for different temperaments, correlating the passions with bodily functions.

[7] "A Discourse setting forth the unhappy condition of the practice of physick in London, and offering some means to put it into a better, for the interest of patients, no less, or rather much more than of physicians" (London, 1670). Goddard (1617?–75) was a fellow of the College of Physicians, lecturer in anatomy before the college, and Gresham professor of physic. During the Civil War he was a physician in Cromwell's army He frequently used his laboratory to make experiments for the Royal Society, and he compounded secret remedies, notably, "Goddard's Drops," which were chiefly ammonia with a few frills He was also credited with having made telescopes His "Discourse concerning Physick " (London, 1668) partially anticipated the tract discussed here, which according to a postscript had actually been written five years before only to be put aside because of the furor caused by the plague and fire.

himself in making choice and important medicines. Moreover, it was not necessary that physicians should put themselves to the drudgery of making common medicines, for the practice of physic could easily be managed with a "tenth part of the things commonly in use, and the remedies reduced accordingly," a change which would improve rather than damage the healing art. Considering how apothecaries censured the practice of physicians and claimed their own prescriptions to be rare secrets, it was high time for physicians to defend themselves. Further advantages of great importance resulted from the physician's administering his own preparations, namely, his possible discovery of more effectual medicaments and his certainty concerning the strength, efficacy and operation of all his medicines It was well known that, let a physician write the same prescription to several apothecary shops, the medicines would vary greatly in their sensible qualities In the meantime, the physician had to answer for all, even though the variations cause a patient's death.

The great objection against physicians making their own medicines was that the apothecaries would be ruined. Yet these persons had taken injurious advantage of physicians by invading the peculiar function of healing, after the physicians had surrendered to them the preparation of medicines Nevertheless, even if physicians made their own medicines, there would still be ample work for apothecaries as they would always be able to practice upon "the meaner sort" With all his criticism, however, Goddard in conclusion denied any intention of branding all apothecaries, of whom many were thoroughly honest and conscientious and therefore had an important function to perform. he sought only to place the healing art on the surest foundation

Still another participant, in the person of the much more obscure George Acton, "Doctor of Physick," joined the argument in 1670.[8] While his contribution was somewhat oblique, it nevertheless indicated the extent to which this lively debate had spread through the medical profession. The author "proved" the possibility of curing a disease without a remedy contrary to the disease or at least contrary to its cause. He denied that heat and cold were the efficient causes of diseases; they were merely the antecedents. Finally, he believed that all fevers could be cured with one medicine, as could all distempers of a hot liver or of a cold stomach, and so forth

These various onslaughts, particularly Merrett's first tract, received an almost immediate reply from one who believed that in counter-attack lay the best defense[9] After noticing Merrett's statement, that it would seem strange to most men that after thirty years' successful practice, he should now end all dealings with the apothecaries, the anonymous author expressed surprise that a reputed discreet person, such as his opponent, should forsake the ancient laudable procedure and quarrel with the whole company of that profession He denied Merrett's contention that the apothecary, being less concerned than the doctor, looked only to his own profit and disregarded the patient's welfare In answer to the conclusion that the greater the patient's charge the greater the apothecary's profit, whereas on the contrary it

8 "A Letter in answer to certain queries and objections made by a learned Galenist, against the theorie and practice of chymical physick, wherein the right method of curing diseases is demonstrated the possibility of an universal medicine evinced, and chymical physick vindicated" (London, 1670). I have not been able to discover anything about this writer

9 "Lex Talionis, sive Vindiciae Pharmacoporum or a short reply to Dr. Merrett's book; and others written against the apothecaries wherein may be discovered the frauds and abuses committed by doctors professing and practicing pharmacy" (London, 1670).

was the physician's interest to cure the patient with the greatest ease, the author reminded his readers that the longer the patient was under the physician's care, the more fees went to the latter Finally, he objected to the account that "other cheats" like "Matthew's Pills" and "Hugh's Powder" had been cried up as universal medicines, "which the contrary to convince . . . were but to lose time."

A second defense of the apothecaries emanated from that rough-and-ready controversialist, Henry Stubbe[10] Less anxious to sift the truth than to engage in verbal fireworks, Stubbe promised to be just to the honorable society of physicians and to vindicate the company of apothecaries After summing up Merrett's charges against the latter, he declared that while some apothecaries might be dishonest, as charged, there was no need to accuse the whole profession in this manner and thus make the honest practitioners suffer. Indeed the latter ought to be the more highly cherished. Moreover, he reminded his readers in response to Merrett's complaints about the "dear bills of apothecaries," the patient that went from the apothecary to "this good doctor" for his medicine, thinking to save by it, would leap from the frying-pan into the fire He, Stubbe, would plead for such apothecaries as used the best ingredients, made their compositions faithfully and dispensed physician's prescriptions conscientiously. As far as the other apothecaries objected to by Merrett were concerned, there was, after all, a sort of people who, so as they might buy cheap, cared not with what they were served or how they were abused and cheated

When Stubbe faced Merrett's suggestion that the patient would greatly benefit by the physician's making his own medicines because the whole charge of the apothecary's bill would be saved since the physician would take nothing for his own medicines, he had a great deal of fun He prophesied that the physicians would charge "handsome sawcy fees", otherwise, how would the scheme hold water? In reply to Merrett's accusation that during the Great Plague the apothecaries took over the whole practice of medicine, he inquired how it came to pass that the "good doctor" himself had no share in curing the plague-stricken Did it show public spirit on the part of the physicians to surrender their practice to the apothecaries? As a matter of fact, Stubbe concluded, physicians and apothecaries were embarked on one bottom, if one sank, the other could not expect much safety To Merrett's declaration that the apothecaries would undo all the chemists in London and possibly ruin the Corporation of Distillers of strong waters, he avowed that the "good doctor," because he feared lest his former chaff would not catch old birds, was calling in more help and leaving no stone unturned that might help to ruin the apothecaries.

In this same year, 1671, a brief compendium of the arguments on the case appeared[11] Although the author, obviously on the side of the angels, had comparatively little to add to what had already been said, he picked out various flaws in Stubbe's tract, stressing especially its "falsities," ill language and

10 "Medice Cura Teipsum! or the Apothecaries Plea in some short and modest animadversions, upon a late tract entituled A Short View of the Frauds and Abuses of the Apothecaries, and the onely remedy by physicians making their own medicines . . From a real well wisher to both societies" (London, 1671). Henry Stubbe, Stubbs or Stubbes (1632–76) was "a professional literary bravo," whose lively literary career gave him more notoriety as a controversialist than reputation as a physician Although he achieved some distinction in the latter capacity, he lacked the professional equipment and connections of the men whom he attacked In addition to the College of Physicians and some of its individual members, the Royal Society also fell under his displeasure

11 "Reflections on a Libel, intituled, a plea for apothecaries" (London, 1671).

defense of the tricks and financial practices of the apothecaries Many quotations from tracts already noted filled its pages, and its chief importance lies in its revelation concerning the extent of the controversy, rather than in any original contribution to the discussion

Contemporaneously, Dr. George Thomson also turned on Henry Stubbe. Nevertheless, at the same time he believed that, while Merrett's book was to be commended for its practical knowledge, Merrett's experimental theories had cost thousands of lives.[12] Thomson scored the members of the College of Physicians heavily "They are persuaded the old way is best, to sit in their chair disputing, scribbling medicines, while others are making them. . . Away, say they, with these new fangled devices of questioning by fact such famous men as we are . . . 'tis enough we have tried again and again, it will bring in a fee." Dr Merrett, "this supposed reformer of the method of physic, thinks it enough to have lashed the apothecaries to have proclaimed their abuses to the world, as if this were enough to expiate his crime . . . he ought . . . to do penance for making a trade of man's life, for perpetuating thus long a fallacious . . . and pernicious mode of practice . . . that 'tis impossible for any man to discharge his duty aright, who makes not his own medicines with his own fingers." The Thomsons deride the boasting of the Merretts in "compounding medicaments better than the whole Company of Apothecaries."

After 1671, the furor subsided, at least so far as tracts were concerned, but in 1675 Dr. Maynwaring again insisted that the preparation and custody of medicines was the proper charge and duty of every physician[13] Likewise, he described the "new" mode of prescribing and filing recipes with apothecaries as an imprudent invention and pernicious innovation. The truth of this was demonstrated to his satisfaction from the treble damage and disadvantage that arose to physician, patient and medical science. Thus he argued for the return to, and general conformity with, the primitive practice, and answered the objections brought against the old custom He likewise discoursed on the excellency of medicines and maintained that skill, knowledge and improvement of medicines were attained not by reading but by practicing, "by preparation and mechanick tryals" The College of Physicians, considering the many inconveniences that emerged from the neglect of medicines, had lately voted it honorable for a physician to prepare his own prescriptions This he applauded as an excellent innovation because medicines were the physician's business Not to be expert in the manual preparation of medicines was an absurd deficiency in a physician as well as very dangerous and often pernicious to the sick

The "imprudent act of our predecessors" in removing pharmacy from the physician's care and management did not perpetually commit their successors If ruin must fall upon one group, better that the apothecaries should suffer than the physicians, since apothecaries had betrayed the trust reposed in them by

[12] "A Check given to the insolent garrulity of Henry Stubbe, etc. Also, some practical observations exhibited for the credit of the true chymical science Lastly, a brief contest between the Thomsons and the Merretts, who are the best physicians" (London, 1671.) Thomson (fl 1648–79) graduated M D from Leyden in 1648 He diligently studied the London plague of 1665 and wrote "Loimologia" (1665) reflecting on the physicians (such as Merrett) who left the city during the visitation. In 1665 also he published "Galeno-pale, or a chymical trial of the Galenists, that their dross in physick may be discovered," protesting against contempt for experience and sole reliance on theory He wrote a number of other medical works, controversial in nature, among which was one opposing excessive blood-letting and which brought him into conflict with Henry Stubbe.

[13] "Praxis Medicorum Antiqua & Nova. The Ancient and Modern Practice of Physick examined, stated, and compared" (London, 1675).

the physicians; therefore, Maynwaring judged it most reasonable that physicians desert them. The safe and speedy recovery of the sick lying in the physician's care was of far greater concern than the profit or maintenance of a particular group of men. The physician that was pharmacopoeian to himself did not delight in the superfluous variety and number of slight medicines, but aimed at a few choice and efficacious ones The new mode of practice was to draw and frame medicines on a piece of paper, modeling them into several forms, varying for every temperament and case. Here the physician ended his work Such a scheme of medicine was then transmitted to some apothecary. Justification of the old practice where the physician prepared his own medicines clearly condemned this new method. This discourse, which was liberally spattered with quotations from Cox,[14] Goddard and Merrett, concluded by elaborating the hazards of the "genteel new mode" of prescribing.

A belated reverberation of the controversy appeared in 1685 in "A Direct Method of Ordering and Curing People of that loathsome disease, the smallpox . . . Being the twenty years practical experience and observations of John Lamport, alias Lampard, practicioner in chyrurgery and physick" Quite apart from his special interest in smallpox, the author referred to the abuses and errors of pretended healers and condemned the existence of too many practicing nurses. If anything may be concluded from Lamport's advertisements of his pills and medicines and the appendix prescribing the proper astrological time to take medicines, he himself was both apothecary and astrologer

As suggested at the outset, the controversy here summarized should not be regarded as an isolated event in the earlier history of medicine Although rather dramatic and concentrated, this flareup only expressed the latent hostility between two groups of healers In addition, it revealed an important and somewhat neglected characteristic of seventeenth century physicians in England—the wide-spread tendency toward reform So often have writers on the history of medicine in particular and of science in general stressed the martyrdom of the reformer, implying that changes have come with theatrical suddenness through the efforts of some outstanding individual, and in spite of the majority of the profession, so often have these "historians" emphasized the achievements of the man "far ahead of his time," that they have distorted the entire evolutionary process It is here important to record the wide-spread support of reform among men not notable as pioneers, among men who personified the rank and file of their profession Obscurantism flourished, in all truth, but the sharp and persistent dichotomy which plays off the lofty genius against massed reaction neglects, if it does not completely deny, the whole realm of historical dynamics.

[14] Probably Thomas Cox (1615–85), a fairly prominent physician of the day, a fellow of the College of Physicians, of which he became president in 1682, and a member of the Royal Society.

RUBBER'S POSITION IN MODERN CIVILIZATION

By P. W. LITCHFIELD

PRESIDENT, THE GOODYEAR TIRE & RUBBER COMPANY

RUBBER'S importance to the modern civilization can be gleaned from its widespread application in tires for motor vehicles—a fact emphasized by our own company's production of its 300,000,000th casing this year. Approaching rubber's place in the sun from another angle—the fact that approximately 4,000,000 workers are engaged in raising, cultivating, collecting, shipping and manufacturing the substance, likewise gives emphasis to rubber's importance

But rubber's contribution to mankind at the one hundredth year of its practicability (dating from Charles Goodyear's discovery of vulcanization, 1839) aggregates far beyond the acceleration of transport and the employment of labor. Through a ceaseless program of scientific research and development, the rubber industry has wrested from the hitherto unknown many secrets which have extended rubber's use into ever-increasing fields with benefit to each new avenue thus entered

Rubber's importance as an insulator in the electric world; as hose and conveyer belts for the industrial transmission of fluids and solids, as a shock absorber for all manner of mechanical vibrations, as an indispensable adjunct to the practices of medicine, surgery and sanitation—all add stature to the eminent place rubber has attained in civilization's onward march

The saturation point of rubber's usefulness has by no means been attained, however. Exploration of its possibilities is not static Developments still fresh from the laboratories, or passing through the final stages of their embryonic perfection in the research workers' test-tubes, give definite promise of a more healthful, enjoyable, convenient life.

Discovery that uncoagulated latex could be whipped into an aereated froth which could be suspended permanently through chemical reaction, has brought about the introduction of mattresses and cushioning material such as Airfoam. Thus man, long accustomed to cushioning his automobile from road shocks with rubber tires, now is beginning to enjoy restful sleep on a mattress of whipped latex which always resumes its original shape, is non-allergic, germ and vermin-repellent His living room furniture and the seats of his passenger car, truck, theater and auditorium are being similarly equipped, with rubber as the cushioning medium

This same material, while comparatively a new product, originally intended primarily for cushioning, already has found practical application in such distantly removed uses as blackboard erasers and powder puffs, illustrating a common characteristic of new rubber products—diversified adaptability

Even more spectacular is the growing utilization of the rubber hydrochloride to which has been applied the copyrighted name, Pliofilm Through a series of chemical processes, physical characteristics of crepe rubber are altered in such a manner that the desirable properties are retained and many objectionable properties are lost. The resulting substance is produced in sheets or rolls over a wide range of gauges, beginning with a gossamer thickness of only 0012 inch.

Being inherently waterproof, practically impervious to moisture, resistant to tear and transparent (if desired) in almost any color of the solar spectrum, Pliofilm at first was used widely for raincoats, umbrellas, tea aprons, shower curtains and as a protective and decorative material for many household applications.

But here again, a rubber product well suited to one field of application has branched out into other important spheres of usefulness To-day the packaging of many commodities has been revolutionized by Pliofilm All manner of foodstuffs, particularly those susceptible to dehydration (such as cheese) and absorption of moisture (such as crackers), now are being packaged in stabilized rubber chloride wrapping

Laminated as lining for paper sacks, Pliofilm is being used to retain the freshness and aroma of fine coffee, laminated to burlap sacks, it is protecting sugar and other bulky granular products from moisture Even oil may be packaged in Pliofilm sacks From the rubber laboratories also has recently come a treatment for women's hosiery that greatly prolongs their usefulness by making them resistant to snagging and running.

Equally important examples could be outlined almost *ad infinitum,* but I believe that these typical applications cited will serve adequately to illustrate my statement that rubber's contribution to mankind goes far beyond the realms of transport and employment

Not only do we communicate over and travel between great distances through the utility of the Hevea tree's latex—it protects our bodies from the elements; it keeps our food fresh and wholesome; it protects us from disease or gives aid in reclaiming us from injury and affliction; it is the fluxing material without which modern living would be either impossible or tremendously restricted

BOOKS ON SCIENCE FOR LAYMEN

A NATION OF ELDERS[1]

THE average span of life of mankind is steadilly increasing. To-day there are more elderly people than ever before; to-morrow we may expect that a still greater percentage of the population will have reached or passed "three score and ten" Ninety years ago, in 1850, but 2 6 per cent of the American people were 65 years or over By 1940 the percentage will have nearly trebled to 6 3 per cent. In 1850 more than *half* the population was under 20 years of age, whereas now but 35 per cent. or slightly more than *one third* of the United States population is under twenty

An era of increased longevity is upon us These shifts may be expected to continue, albeit with reduced tempo, for there is a biologic limit to the normal span of life The consequences of these changes which are making us a nation of elders reach far and wide and affect every field of human endeavor. Medical, economic, sociologic and political problems are pressing for solution. The mind of the nation is changing· it is growing older Perhaps this implies it is growing wiser, perhaps not. We hope it is, for the hope to live long and usefully is well-nigh universal

The problems of old age are not new, but the urgency for their solution has never been as great as it is now. If we as a people are to gain by these consequences of preventive medicine (every life saved from premature death is a potential senescent) we must need to know far more than we do now concerning the problems of ageing The appearance of this extremely comprehensive volume is most timely.

Ageing is a biologic process common to all living organisms—perhaps a process common to all matter. Although the inception of ageing starts with the conception of a new organism, the changes are long submerged in the conspicuous activities of growth, development and maturation It is only after maturity has been reached that senescence makes itself felt as an active process This publication considers the problems of ageing from a broad biologic view-point The evidences of senescence in all forms of life are discussed Ageing in plants, protozoa and insects differs from the processes observed in mammals and higher forms of life The changes inherent with old age in the various tissues and systems of the body are probed and exhaustively analyzed

Although prepared primarily for physicians and biologists, the book contains much of great interest to the general reader Dr Cowdry's careful selection of the twenty-six eminent contributors has resulted in a most scholarly and thorough presentation Each chapter includes a brief but well-chosen bibliography Medicine must needs concern itself more and more with the particular problems of health maintenance in the aged and with the degenerative diseases characteristic of later life. Geriatrics has a significant future. It is upon biologic foundations such as those summarized in this book that the application of medical science rests.

Despite the extensive scope and ambitious program of the work in recording the intensive studies of many specialists, the chief value of the book lies in the implication and recognition of the numberless problems remaining unanswered. It attacks the problems from the roots

[1] *Problems of Ageing Biologic and Medical Aspects.* Edited by Edmund V. Cowdry. Illustrated xxx + 758 pp. $10 00 Published for the Josiah Macy, Jr, Foundation by Williams and Wilkins Company.

by asking the fundamental questions: What and why are the biologic mechanisms of ageing?

E. J. STIEGLITZ

ANTS VS. MEN[1]

JUST at the moment when our present civilization appears to hang in the balance comes this book It treats of a subject that has always intrigued curiosity of biologists and laymen alike—the concerted behavior of ants as it illustrates the similarities and differences between their social life and that of the paragon of organization among the primates, *Homo sapiens*[2]

The ants are geologically far older than man, for we know that they made their appearance on earth well before Tertiary times. They were, in fact, abundant some 60 million years ago and at that time were essentially similar to the present living species in their bodily structure and unquestionably also in their habits Thus, a type of social organization that has been so successful and weathered the vicissitudes of such an interminable period without any fundamental changes should be worthy of searching comparison with the vagaries of human "progress." The latter, now sky-rocketing about with the vigor of early youth, still has some ten thousand times longer to go before it reaches the ripe age of the ants' social history Will our own civilization land hopelessly cracked up, or will we finally adopt the mechanized behavior of the ant that has proven so satisfactory for a type of purely instinctive invertebrate animal?

Before dealing with this comparative behavior "Of Ants and Men" Dr Haskins reviews the origin and evolution of ants as fully as may be in the light of our present knowledge, and gives an account of the present organization of the colony in the several groups of the family Formicidae. He shows how the more individualistic and primitive types have given way before the more specialized ones whose dominance appears to be correlated with the disappearance of individual variations in behavior

There is, of course, an account of dulosis, or slavery, among ants, of parasitic ants and of the numerous myrmecophiles that have taken up their abode in ant-nests The consequences of these social phenomena are then considered at some length in connection with the life and prosperity of the colony and their final effect upon the species concerned Several pages are devoted to a detailed account of two species (*Pheidole megacephala* and *Iridomyrmex humilis*) that have spread widely in warm countries during recent times, driving out the indigenous ant-fauna over the extensive areas that they have exploited Finally, meeting in Madeira in a fight to the finish where the militant Pheidole had already taken possession, an unexpected outcome has been the usurpation of the island by the gentle Iridomyrmex which now holds sway after having completely ousted the earlier invaders Such occurrences offer much food for thought in connection with human behavior, and the author points out many additional analogies of sociological interest, particularly with reference to parasitism, slavery and conquest.

As he finds that the organization of the ant colony appears to be most closely analogous to the several forms of totalitarian government in man, such as communism and fascism, the author appears to believe that the latter represents a later evolutionary stage in human relations, especially as this is the pattern among the higher groups of ants As we find the more "democratic" primitive

[1] *Of Ants and Men.* By Caryl P Haskins Illustrated. vii + 244 pp $2 75. Prentice Hall, Inc., New York.

[2] Or, as some taxonomists prefer to call him, *Homo americanus* var. *europaeus*, thus sidestepping the connotation of sapience.

ants giving way to the more "totalitarian" higher types, we may, therefore, perhaps anticipate an enduring multimillennium of totalitarianism for the human species. Whereupon I feel tempted to revive the Mosaic legend that God created man in his own image, and, we trust, with a less restricted intellectual horizon than that enjoyed by the ants who have been satisfied with fecundity, conquest and a consequent domination of the insect world

The book is extremely well written, and although the author is primarily a general physiologist who has undertaken the study of ants as a secondary interest, there are few errors that the reviewer has been able to detect It is heartily recommended to the wide audience for which it is intended, including all biologists, sociologists and those really interested in general science In view of the present state of our human world, it has appeared at a particularly opportune time to disseminate much information not extensively known and to draw many illuminating comparisons between ants and men.

CHARLES T. BRUES

HUMAN HEREDITY[1]

THIS book is an outstanding achievement in the popularization of science Mr Scheinfeld is a layman, not a scientist Nevertheless, he has written an account of the difficult science of human heredity that is sound, interesting and highly informative The lay reader will certainly learn much from "You and Heredity" But thanks to the expert collaboration of Dr Schweizer, the book should also satisfy the critically minded geneticist, and serve to broaden the teaching biologist's knowledge of many unusual phases of human biology. Furthermore, whoever the reader, he will be entertained by the vivid and piquant tables and diagrams (many in color) and the sprightly style.

Since the author is not a professional scientist it is of interest to inquire as to the motivation that led him to write this book. "When I began my study of the subject, it was solely for the purpose of utilizing some facts of human heredity in a projected work of fiction. Before long I discovered that the findings in the field so completely shattered my own preconceived notions and the ideas held by all but an initiated few as to obliterate my original plans I became convinced that the most interesting task before me was to acquire as thorough a knowledge of this subject as I could and then, in some way, to communicate it to others" This approach to the study and the popularization of a scientific problem is significant in respect to the relation between science and society. It presents the impact of science on culture in a somewhat novel form, and it introduces a rather new type of factor aiding the diffusion of the fruits of scientific research from the restricted field of the laboratory to wide-spread social acceptance

The book begins with an introduction to the bare essentials of genetic principles, and then goes on to discuss in detail the inheritance of eye, hair and skin color, of features, body form and structure, and of many pathological conditions ranging from color-blindness to peroneal muscular atrophy Constant reference to the genetic problems and probable results of various human matings make these sections of the volume particularly appealing to those who take parenthood seriously. Much of the remainder of the book is devoted to an illuminating discussion of questions having social significance, such as the interaction of heredity and environment in the determination of intelligence, crime, personality and certain diseases, and the problems of eugen-

[1] *You and Heredity.* By Amram Scheinfeld, assisted in the genetics sections by Dr. Morton D Schweizer. Illustrated xvii + 434 pp. $3.75. Frederick A Stokes and Company.

ics and of "race." Mr Scheinfeld's main conclusion from his study of the social aspects of his subject is a very significant one; " . at the moment we have no need to stake our hopes for an improved mankind on future genetic findings or on radical changes in our biological make-up . . We have in our biologic genes now in circulation, . . . all the potentialities for a race of supermen—*if we can properly direct and control our environment*" (Author's italics) This is a conclusion to be especially pondered by eugenists

"You and Heredity" is not without some faults. Students of evolution, for example, will question the author's claim that Darwin gave complete credence to the theory of the inheritance of acquired characteristics, and many will not agree with all his political views But these shortcomings are of minor importance What strikes one most is the many excellences of the book, and it is these that are its recommendation to any one interested in the subject of human heredity

ALEXANDER SANDOW

A SCHOLARLY BOOK FOR SCHOLARS[1]

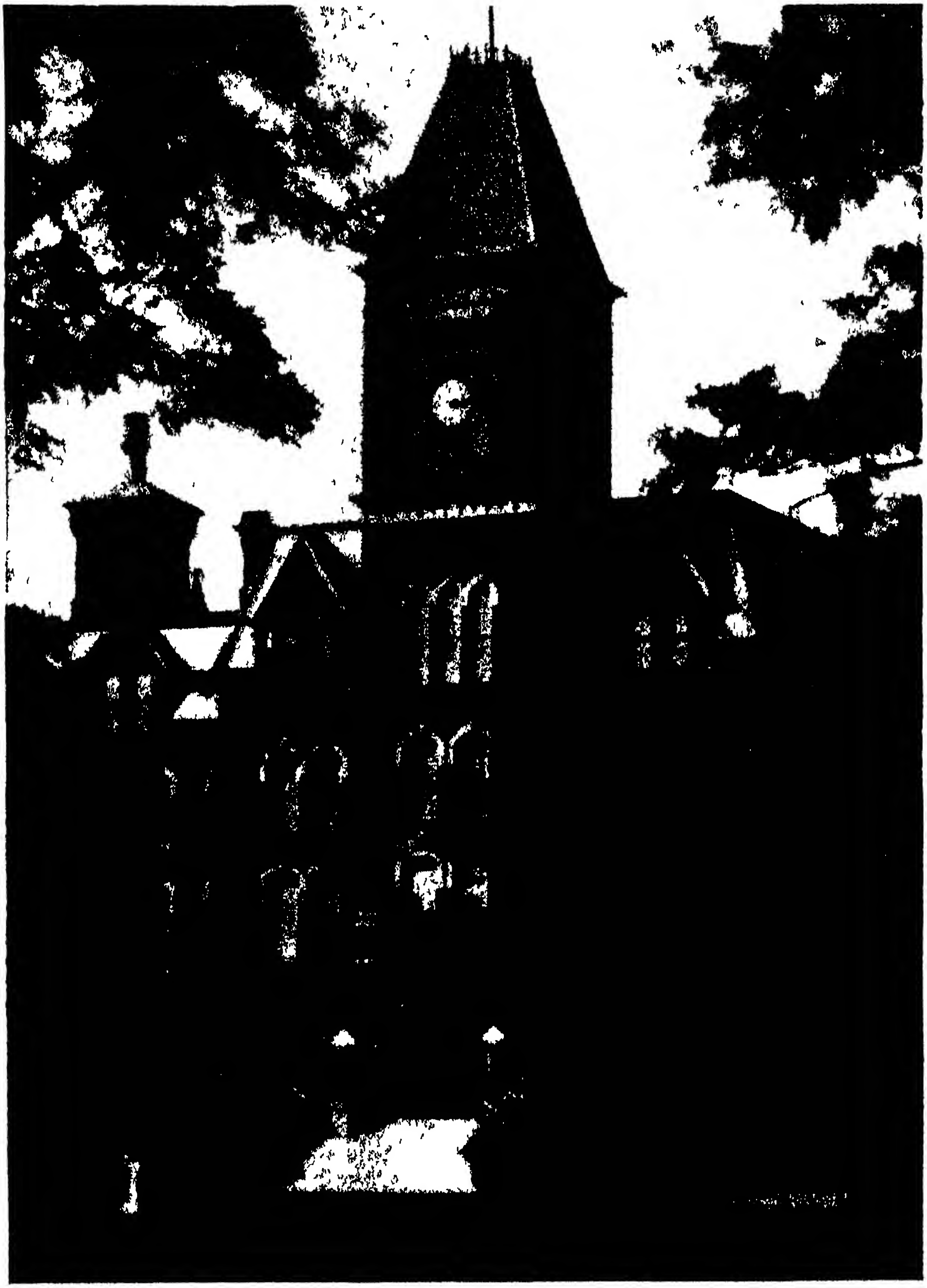
THIS, "The North American Assault on the Canadian Forest," is not the first book on the ravaging of a great resource by covetous gentlemen It is, however, one of the most carefully detailed and worked out of the lot Perhaps a too great realization of the danger of relating this "special phase of economic history" in accordance with a method that is romantic leads the editor, who is the author of the major section of the book, to be over-cautious in his presentation. There are for the layman perhaps three major purposes in a book of history. The first is to relate facts; the second is to present a fascinating and vigorous story, and the third is to reform. This book clings tenaciously to the first. There are two important human elements that seem to have been lost sight of in the creation of this work At least two The first of these is the building of tremendous fortunes and, in some cases, the loss of these This phase of the whole panorama, the authors have either failed to see or else they have feared to deviate from the straight and narrow processes of history-making to present a possible, colorful picture The second of these is the life—in some cases the exaltation, in others the degradation—of the laborers who made possible the great exploit

Regarding the features that pertain to reform, perhaps the work has been done by Thorstein Veblen, at least so far as the forests this side of the Canadian border are concerned Anyway, the attempt to teach a lesson by picturing the processes by which a great resource is despoiled would be only futile, probably. The layman, however, expects the world to be made over according to some idealistic pattern, and he therefore likes a homily in what he reads But this book is not written for the average reader; it is written for students of economic and factual history It should be noted, therefore, that an important purpose of history writing has been fulfilled. The facts are well presented, and the economic phases of the whole development are likewise revealed It is refreshing to see that at least historians on the Canadian side are interested in so important a matter as the economics of the situation.

To summarize, it may be said that so fine a work will probably fail to meet the needs of the average reader, it is a book designed for scholars rather. It is one of a series to which significant individuals are devoting their time and effort.

J E THORNTON

[1] *The North American Assault on the Canadian Forest.* By Lower, Carrothers, Saunders Illustrated. xxvii + 377 pp. $3 75. Yale University Press.



UNIVERSITY HALL OF THE OHIO STATE UNIVERSITY

THE OLDEST BUILDING ON THE CAMPUS JOINT SESSIONS OF AMERICAN SOCIFTY OF ZOOLOGISTS AND GENETICS SOCIETY OF AMERICA WILL BE HELD IN ITS AUDITORIUM

THE PROGRESS OF SCIENCE

SCIENTISTS ASSEMBLE AT COLUMBUS

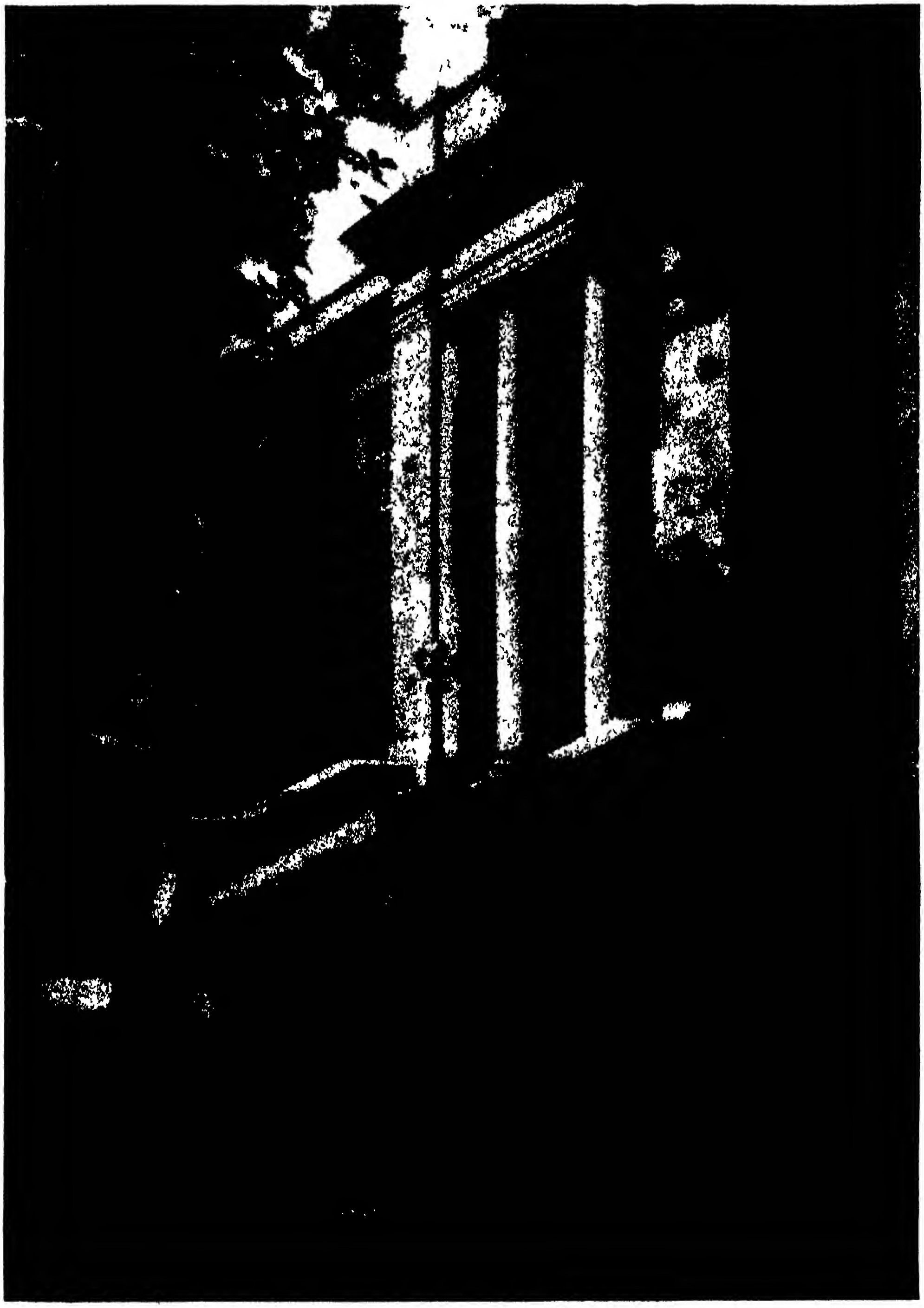
IMMEDIATELY after next Christmas scientists from all parts of the country, five thousand strong, will be on their way toward Columbus, Ohio, to attend the one hundred fifth meeting of the American Association for the Advancement of Science, which will be held from December 27 to January 2.

During the first seventy years of the existence of the association (it was organized in 1848), it could meet in any university town, for its programs consisted of a dozen or two sessions at which a few general addresses were delivered and a few score papers were presented. With the enormous expansion of science during the past thirty years the membership of the association has grown until it now exceeds twenty thousand, and the programs of its meetings have increased proportionally. At the meeting in Columbus about two hundred sessions will be held before which approximately sixteen hundred papers will be presented. The details necessary for arranging these programs are largely in charge of the secretaries of the sixteen sections of the association and of the secretaries of those of the one hundred sixty-six affiliated and associated societies that join in the meeting.

In order to provide facilities for presenting the programs of these sections and cooperating societies, it is necessary to have ready for simultaneous use about sixty meeting rooms, each equipped with a stereopticon projector and having an operator always available for darkening the room and serving the machine, and year by year steadily increasing numbers of motion picture projection machines are required, for the sequences in which phenomena occur are sometimes of the highest importance.

The foregoing statement of the accommodations and facilities that are necessary for meetings of the association explain why they must be held in such large cities as Columbus. In important respects Columbus is an ideal city for a meeting of the association, for it is located near the center of population of the country and includes within three miles of its center the Ohio State University with fifty buildings and more than seventeen thousand students. This great institution provides not only meeting rooms and numerous facilities, but the 1,100 members of its teaching staff, as well as its graduate students, furnish numerous participants in the programs and large audiences. Moreover, the Ohio Wesleyan University is only twenty-two miles away. Virginia has been known as the home of presidents of the United States, Ohio is preeminently the home of colleges. It is said that whenever its early ministers were in doubt they would found colleges. However that may be, nearly every town of any size in Ohio is the seat of a college where science is taught, whatever may have been the primary purpose of its founding. The meeting of the association in Columbus will be an inspiration to all these centers.

How fast the world changes in our day as a consequence of science and its applications! Central Ohio was opened for settlement in 1787, and the first residence, a log cabin, was erected in 1798 in the area now occupied by Columbus. In 1812 the Congress of the United States appropriated certain "refugee lands" in that region for the use of Canadians and Nova Scotians who had sympathized with the Colonists in their struggle for independence in the Revolutionary War. The Borough of Columbus was incorpo-



MUSEUM OF THE OHIO STATE ARCHAEOLOGICAL AND HISTORICAL SOCIETY.
THE MEETINGS OF THE ECOLOGICAL SOCIETY OF AMERICA WILL BE HELD IN THIS BUILDING

rated in 1816 In 1834 Columbus, with a population of 3,500, was incorporated as a city. At the outbreak of the Civil War its population was only 18,000, in 1900 it was about 125,000, now it is about 500,000, a four-fold increase in forty years

It is not difficult to explain the development of Columbus and other large cities in Ohio The state has a fertile soil, great resources in petroleum and natural gas, and enormous quantities of coal Indeed, in one area there are forty seams of coal that were laid down successively in the days when the waters of shallow seas periodically spread over what is now the central part of the United States Fortune added to these almost unparalleled natural resources by connecting the enormous iron ore deposits of the Lake Superior region with the coal areas of the Ohio valley by the Great Lakes Finally, Ohio was settled by hardy and progressive pioneers

One thing remained for the development of a great industrial state, and that was science It came and worked a miracle of transformation that no one could have anticipated a century ago Physical evidences of accomplishments are obvious and often are taken as the measure of the progress of civilization But really they are the means to finer ends, as the roof and walls of a house are only to shut out the elements and the world from the sacred home that is within At the meeting in Columbus the boasting will be of the achievements of the mind—of explorations into remote parts of space and into inner recesses of matter, of the long history of the earth and of its future, of the evolution of life and of the curing of disease, of the rise of man and of the progress of civilization Instead of being austere, except in its insistence on the truth, science is joyous and optimistic The general programs of the meeting prove the statement. The address of the retiring president of the association, Dr Wesley C Mitchell, of Columbia University, is on "The Public Relations of Science" The title of the

HORTICULTURE AND FORESTRY BUILDING
WHICH WILL HOUSE THE HORTICULTURAL SCIENCES

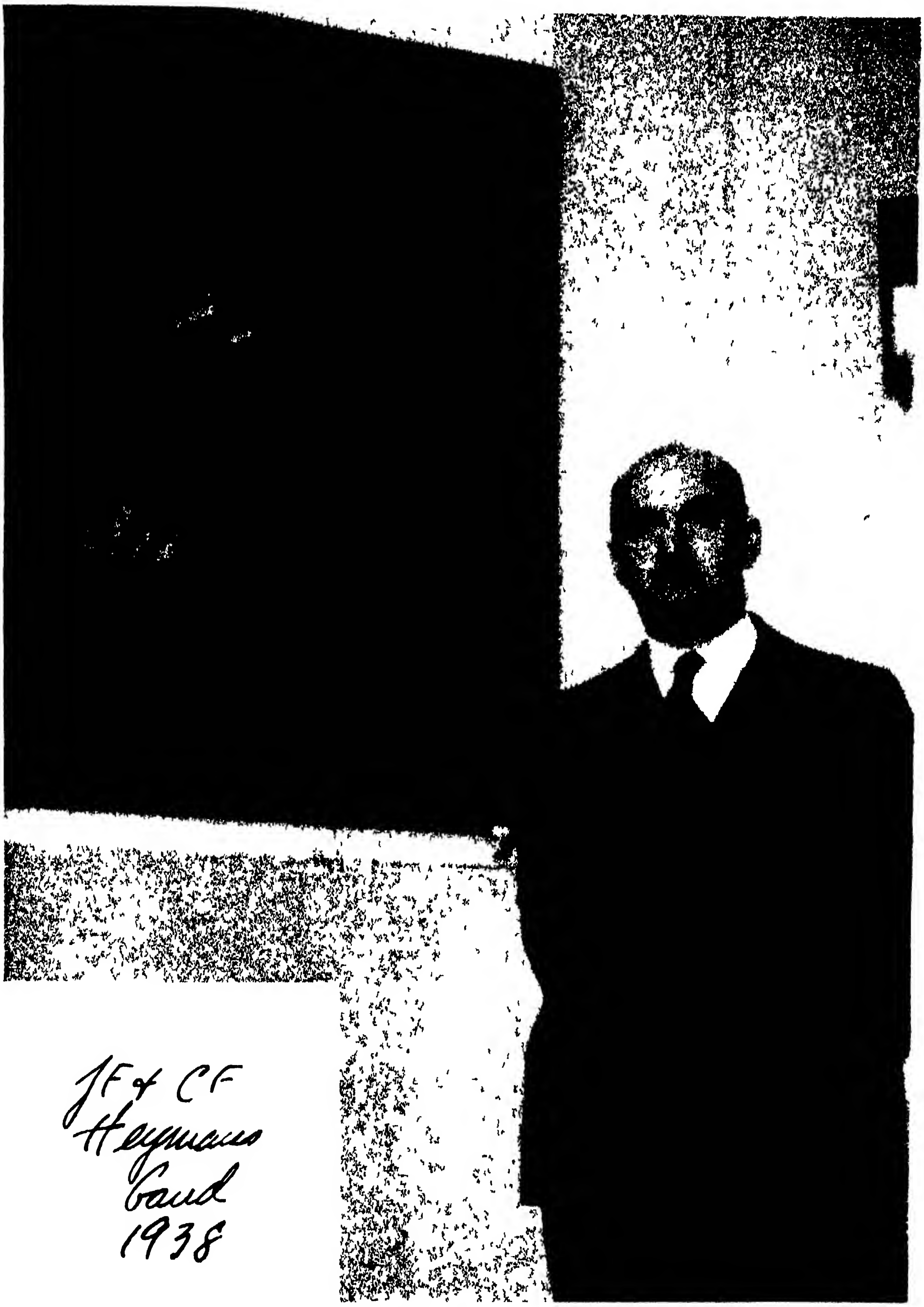
annual Sigma Xi address, to be delivered by Dr Kirtley F Mather, of Harvard University, is "The Future of Man as an Inhabitant of the Earth" And the annual address under the auspices of Phi Beta Kappa is by Dean Marjorie Nicolson, of Smith College, on "Science and Literature"

Science is generous, every discovery being shared gladly with the whole world No preacher or priest will breathe more truly the Christmas spirit of Peace on Earth and Good Will to Men than will the scientists in their meeting in Columbus, Ohio, from December 27 to January 2 Indeed, many troubled minds are looking anxiously toward science with the hope that it will be able to provide a new and better foundation for ethics and possibly religion F R MOULTON

PROFESSOR CORNEILLE HEYMANS, NOBEL LAUREATE IN PHYSIOLOGY AND MEDICINE FOR 1938

ACCORDING to Oswald Schmideberg, the founder of the science of pharmacology, the main purpose of those working in this field should be the elucidation of physiological phenomena by studying the reactions of living systems to chemical agents The depth of this conception is shown by the caliber of the contributions which those who have been guided by it have been able to make to the sum of human knowledge, and no more striking commentary could be desired than this, that the Nobel Committee, custodians of the highest award that can come to a medical scientist, having in 1936 honored two pharmacologists, Henry Dale and Otto Loewi, for their work on humoral transmission of the nerve impulse, now award the prize for 1938 to Corneille Heymans, professor of pharmacology in the University of Ghent, for the new light that his studies have cast on the regulation of respiration and the influence of drugs upon it

The name of Corneille Heymans first became widely known when, in a paper published in 1927, his father and he announced the discovery of respiratory changes produced reflexly by alterations either in the pressure or in the chemical composition of the blood in the arch of the aorta Almost simultaneously, in publications stimulated by H E Hering's discovery of the importance of carotid sinus reflexes to the control of blood-pressure and heart rate, attention was directed by Danielopolu and his collaborators to respiratory reflexes, similar in essential respects to those described by Heymans père et fils, but emanating from the carotid sinus region instead of the aortic arch Corneille Heymans then set out to investigate the carotid reflex zone, as he told me (and like most who have come to work in this field) in the most skeptical frame of mind possible, but it was not long until he had convinced himself that this source of reflexes is certainly as important as the aortic region, and at the same time is vastly more accessible to experimental approach He confirmed Hering's results with respect to the "check-rein" effect exerted on heart rate and vasomotor center by the reflexes aroused in the carotid sinuses and aorta by increase in intra-arterial pressure He showed clearly, for the first time, that the respiratory center responds like the vasomotor in this respect, being reflexly inhibited by rise in intracarotid pressure, reflexly stimulated by a fall But his entirely new and undoubtedly most important contribution is the discovery—in carotids as well as aorta—of another reflex system responsive to chemical agents and not to pressure, and producing stimulant instead of inhibitory effects upon blood-pressure and respiration He demonstrated that these chemoreflexes arise, not in the carotid sinuses (as the pressure reflexes do), but



DR. CORNEILLE HEYMANS BY THE MEMORIAL TO HIS FATHER

THE LATE PROFESSOR J. F. HEYMANS, IN WHOSE HONOR THE J. F. HEYMANS INSTITUTE WAS FOUNDED. THE PLAQUE IS IN THE LOBBY OF THE INSTITUTE BUILDING.

THE J. F. HEYMANS INSTITUTE AT GHENT, BELGIUM

in some proximal part of the external carotid system, and he accepted De Castro's claim, based on morphological grounds, that the chemically sensitive receptors are located in the carotid body, which has subsequently been proved true He showed that the chemoreceptors can be stimulated by all three of the main chemical influences that physiologists have long associated with the automatic control of respiration, namely oxygen-lack, increased acidity and increased carbon dioxide tension in the arterial blood Thus he introduced an entirely new element into discussions of the physiology of respiration He demonstrated that the stimulant effects of oxygen-lack on respiration and circulation are dominantly if not exclusively due to these reflexes, the direct effect on the nerve cells of the centers being a depressant one—a conception that has greatly clarified our understanding of this subject, that already has had an influence upon psychiatry, as evidenced in the explanations now current for the beneficial effects of metrazol and insulin in the treatment of mental diseases, and that will almost inevitably have important bearing upon aviation medicine He found that a number of drug actions, such as the respiratory and circulatory stimulant effects of cyanides, sulfides and small doses of lobeline and nicotine, are exerted on these chemoreceptors and not, as previously supposed, on the centers themselves His work has been repeated (again in the most skeptical frame of mind possible) by a number of others, and no one who has remained in the field long enough to acquire the requisite technique has failed to confirm his general conclusions So thoroughly has Heymans explored this new physiological territory that it is scarcely possible now to make an observation that has not already been made and recorded by him There is room for difference of opinion about some of the fundamental points involved, largely because there are greater differences among individual animals, among different species and under different experimental conditions, than he has taken cognizance of in drawing conclusions from his experiments Yet even though final answers to the

questions raised by his pioneer experiments are not yet at hand and will not be until a considerable amount of laborious experimentation has been carried out, this can not detract from the service he has rendered the cause of medical science by discovering a chemoreflex system previously unknown and thus stimulating new types of thought and investigation I am sure that his thousands of friends and admirers in this country will join in congratulating the Nobel Committee on their happy choice and in extending to the new laureate heartiest felicitations as well as best wishes for the future

The course of events leading to this pleasant culmination might perhaps be studied with profit by those who are entrusted with the destinies of the various peoples of the world a Belgian takes up a challenge derived by a Rumanian from the writings of a German and is rewarded by the Swedes, while the entire scientific world shouts its approval Differences of opinion among the nations can still be settled amicably and yet with dignity and profit to all concerned —in the realm of science

CARL F SCHMIDT
UNIVERSITY OF PENNSYLVANIA

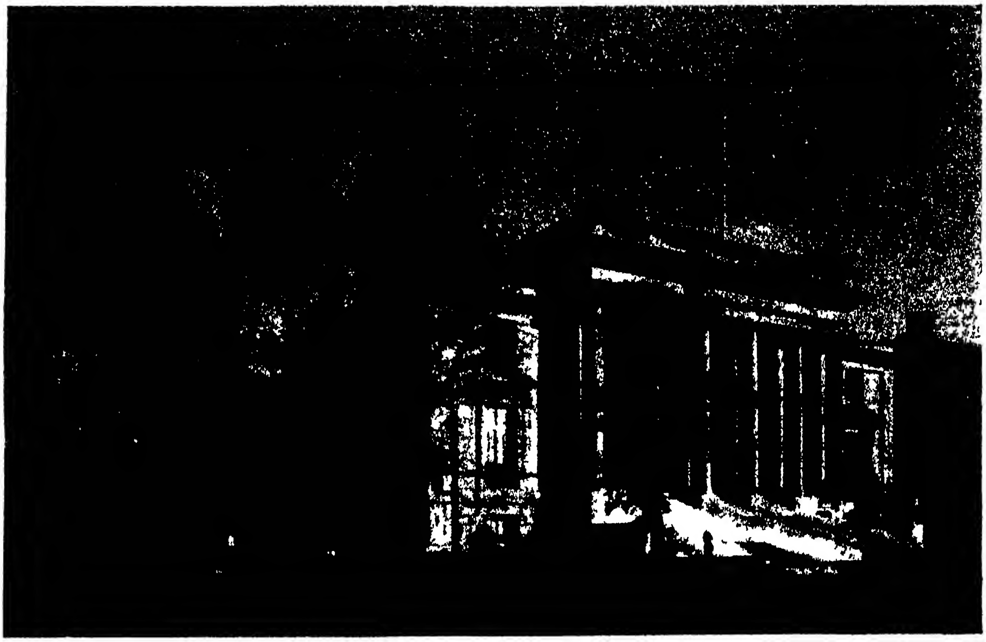
THE FORTHCOMING EXHIBITION AT THE CARNEGIE INSTITUTION OF WASHINGTON

ONE of the interesting scientific exhibitions of the year will be the annual exhibition of recent research developments by the Carnegie Institution of Washington The institution, following its usual custom, will present the results of some of its current researches at its next exhibition, which will be held at its Administration Building, Sixteenth and P Streets, N W, Washington, D C The exhibition will be opened to the public on Saturday evening, December 16, and will remain open on the following Sunday and Monday

In past years the range of its exhibits have covered a wide field, as is to be expected in view of the scope of the scientific activities of the Carnegie Institution itself Founded in 1902 by Andrew Carnegie and reincorporated by act of the Congress of the United States in 1904, with Elihu Root as chairman of its board of trustees and Daniel Coit Gilman as its first president, its general purposes are "To encourage in the broadest and most liberal manner investigation, research, and discovery, and the application of knowledge to the improvement of mankind"

In its earliest stages these objectives of the institution were accomplished through grants of funds for specific researches, but later efforts were directed towards certain major projects, the pursuit of which required longer periods, increased staff and greater concentration of funds This tendency towards concentration on important complex problems, which could only be attacked effectively through the united and correlated efforts of groups of scientifically trained individuals, led to the organization of departments and divisions devoted each to its general subject under the leadership of able and experienced investigators More especially was this true since the institution attempts to advance fundamental research in fields not normally covered by other agencies

In line with these policies of the institution, its Division of Animal Biology, under Dr George L Streeter, comprises the Nutrition Laboratory in Boston, the Department of Genetics with its Station for Experimental Evolution and Eugenics Record Office at Cold Spring Harbor, Long Island, the Department of Embryology in Baltimore, and the Tortugas



THE ADMINISTRATION BUILDING OF THE CARNEGIE INSTITUTION OF WASHINGTON
WHERE THE EXHIBITS WILL BE HELD IN DECEMBER

Marine Laboratory in Florida The Division of Plant Biology, under Dr H A Spoehr, includes the Desert Laboratory at Tucson, Arizona, and Department of Botanical Research, the Coastal Laboratory at Carmel, and the Central Laboratory for Plant Physiology at Stanford This division also operates dune gardens at Santa Barbara, Calif, and transplant gardens at intervals from the base to the summit of Pike's Peak Extensive palaeobotanical researches and studies of historical climatology have long been carried on also by this division

The Geophysical Laboratory, under Dr L H Adams, and the Department of Terrestrial Magnetism, under Dr J A Fleming, are both in Washington, D C The institution also operates magnetic and electrical observatories in Peru and Australia The Mount Wilson Observatory, under Dr W S Adams, is at Pasadena, Calif The Division of Historical Research, under Dr A V Kidder, which includes the Sections of Aboriginal History, Post Columbian History and the History of Science, is in Cambridge, Mass

The results of the numerous researches already completed or currently in progress by the large staff of the institution in its several departments and divisions appear in current scientific magazines of various societies, and in hundreds of volumes of monographs and other scientific publications of the institution itself which are sent gratuitously to all the principal libraries of the world, the object of the distribution being to make the research materials readily available to scientists and others interested, wherever they may be

This same objective of the wider application of knowledge is the guiding purpose of the institution in its annual exhibition of some of the more recent

advances in science, which will be open to public view in Washington in December, together with a series of public lectures generally related to the subjects of the exhibits demonstrated at that time T H D

AWARD OF THE RUMFORD MEDALS TO PROFESSOR GEORGE RUSSELL HARRISON

IN the year 1753 in a farmhouse in North Woburn, Mass., there was born to Benjamin Thompson and his wife, Ruth Simonds Thompson, a son named Benjamin.

During his boyhood the lad showed an intense interest in scientific matters, attended scientific lectures at Harvard College, and later taught school at Concord, N H

In the process of time he became a distinguished scientist and philanthropist, and for his researches was renowned in Bavaria, Great Britain and the United States An outstanding achievement was the overthrow of the then prevailing caloric theory of heat and the substitution for it of the dynamical theory

Created a prince by Prince Maximilian, he chose the title "Count Rumford" from Rumford, N H, now Concord

In a letter dated July 12, 1796, to John Adams, then president of the American Academy of Arts and Sciences, Count Rumford wrote as follows.

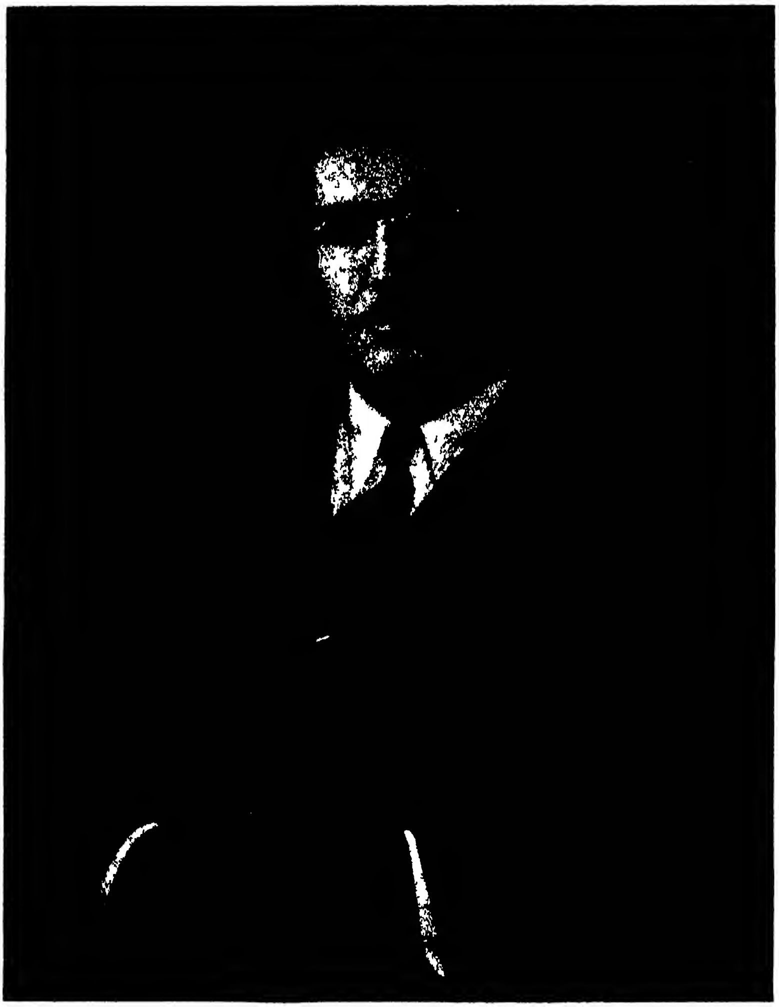
Sir,—Desirous of contributing efficaciously to the advancement of a branch of science which has long employed my attention, and which appears to me to be of the highest importance to mankind, and wishing at the same time to leave a lasting testimony of my respect for the American Academy of Arts and Sciences, I take the liberty to request that the Academy would do me the honour to accept of Five Thousand Dollars, three per cent stock in the funds of the United States of North America, which Stock I have actually purchased, and which I beg leave to transfer to the Fellows of the Academy, to the end that the interest of the same may be by them, and by their successors, received from time to time, forever, and the amount of the same applied and given once every second year, as a premium, to the author of the most important discovery or useful improvement xxx on Heat, or on Light, the preference always being given to such discoveries as shall, in the opinion of the Academy, tend most to promote the good of mankind

The receipt of this gift of $5,000 to the academy proved even more far-reaching in its influence than Count Rumford had anticipated The principal of this fund now stands in excess of $84,000 The proceeds are used not only for the Rumford Medals but also for Rumford Grants for the purchase of apparatus by those who are conducting researches in heat or light

The first award of the Rumford Medals was made in 1839, just one hundred years ago To the present time 38 individuals have received this honor On the list of "Medalists" of thirty years ago, we find the names of, among others, Alvan Clark, Henry Augustus Rowland, Albert Abraham Michelson, Edward Charles Pickering, Thomas Alva Edison, James Edward Keller, Elihu Thomson, George Ellery Hale, Ernest Fox Nichols and Edward Goodrich Acheson

On October 11, 1939, the thirty-ninth award was made to Professor George Russell Harrison, professor of physics at the Massachusetts Institute of Technology

The committee felt unquestionably justified in its action for the following reasons Although Professor Harrison is as yet a young man he has, in the last seventeen years, published thirty-five papers *in his own name* and eleven in collaboration with others, and he has recently written a book "Atoms in Action"—these forty-seven publications being all extremely valuable and, almost without exception, in spectroscopy, which is to-day one of the most important branches in the science of light



PROFESSOR GEORGE RUSSELL HARRISON
PROFESSOR OF PHYSICS AND DIRECTOR OF THE RESEARCH LABORATORY OF EXPERIMENTAL PHYSICS AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The outstanding achievements, in which Professor Harrison's mind has been the guiding influence, are three.

First. The development of an "automatic wave-length comparator," a machine which automatically measures, reduces and records wave-lengths and superposes upon the film on which these are recorded a microphotometer trace which shows the intensity and physical characteristics of the lines Complex spectrograms may thus be measured from 10 to 200 times as fast as was hitherto possible With the aid of this instrument a volume of wave-length tables covering 109,725 lines has been prepared

To those spectroscopists who for hundreds of hours in their lives have been seated at the microscope, estimating visually the intensities of spectrum lines appearing on the photographic plate, setting the cross-hairs of the comparator upon these lines and later laboriously

calculating their wave-lengths, it appears nothing short of miraculous that this new machine performs synchronously the three processes above mentioned and completes the operations in but a fraction of the time previously required

Second The invention of an automatic subtracting machine for sorting wave-number intervals, for use in the analysis of atomic energy levels

Third The production of an interval sorter, which takes the intervals shown by the second machine to be important and combing wave-length lists very rapidly, picks out all pairs of lines showing these intervals

The development of these three machines alone, apart from numerous other achievements, constitutes a contribution to the field of spectroscopy, which places the most recently elected Rumford Medalist quite properly among the brilliant and distinguished scientists who have been recipients of this honor

It may be of interest to the public to know that, at this October meeting, the American Academy, for the first time in its history, "went on the air" Dr Harlow Shapley, director of the Harvard Observatory and president of the academy, presided, the medals were presented by the writer of this article, and Dr Harrison then delivered an address upon the subject, "New Methods in Spectroscopy"

N A KENT

BOSTON UNIVERSITY

ONE OF THE MEDALS GRANTED TO PROFESSOR HARRISON

SEEDLESS FRUITS PRODUCED BY CHEMICALS

EVERY one is familiar with the fact that there are seedless fruits as, for instance, oranges, grapes, bananas and even cucumbers, but it is perhaps not so well known that it is possible to produce seedless fruits artificially by treating the flowers with chemicals To be sure, not every plant can be made to produce fruits by this treatment, but success has been attained with a good many species

The tomato was the first seedless fruit successfully produced by chemicals When the flower buds were nearly ready to open they were opened with a pair of forceps and the pollen-bearing stamens removed Upon the pistil or sometimes upon the cut surface of the style was placed the chemical mixed with lanolin (fat from sheep wool) The lanolin served merely as a carrier for the

chemical The bud was closed again, and in a rather high percentage of treatments there resulted a fruit which was perfectly normal in every way except there were no seeds Sometimes the fruits were small and solid without any seed cavities, but that was rather unusual The taste of these seedless fruits was no different from that of the seeded fruits.

Peppers, crookneck summer squash, egg plants and watermelon have been produced in a similar way Not only fleshy fruits but also dry fruits have been produced by treating the flowers with chemicals By injecting a dilute solution of the chemical into the pistil of the flower, tobacco fruits were produced that were nearly full size, but without seeds Another variation of the method has been to spray the flowers with the chemical This method has usually been employed with plants that have the two sexes in separate flowers, in which case there is no necessity of removing the stamens Seedless holly berries and strawberries have been produced by spraying the flowers

The chemicals which have been found to be effective are phenylacetic acid, indole-acetic acid, indole-butyric acid and naphthalene acetic acid These chemicals, together with a number of others, have been found to produce growth in plants and are generally spoken of as growth-promoting substances Several of them have been used to produce roots on cuttings

Extracts of pollen from several plants have also been used to produce seedless fruits The extract was mixed with lanolin and the paste applied to the pistils with the result that in many instances fruits resulted

Besides producing seedless fruits, which may or may not be of any significance in itself, these experiments are of considerable scientific importance because they furnish the botanist with much-needed information about the development of fruits Recent investigations have shown that there are naturally occurring growth-promoting substances, or hormones, in flowers and fruits It has been found that the pistil, pollen and the seeds contain a considerable quantity of growth hormones, and it was further discovered that the pistils from varieties of oranges and grapes that naturally produce seedless fruits

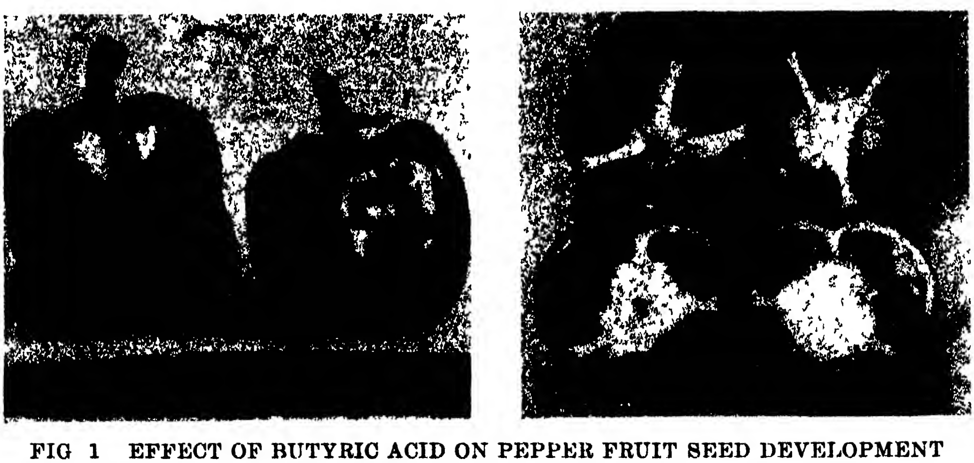


FIG 1 EFFECT OF BUTYRIC ACID ON PEPPER FRUIT SEED DEVELOPMENT
(*Left*) THE PEPPER FRUIT WITH THE TAG WAS PRODUCED BY TREATING THE FLOWER WITH INDOLE BUTYRIC ACID THE OTHER FRUIT IS NORMAL (*Right*) THIS REPRESENTS CROSS SECTIONS FROM THE PARTHENOCARPIC FRUITS IN THE ADJACENT PICTURE NOTE ABSENCE OF SEEDS THE LOWER FIGURES REPRESENT NORMAL FRUITS WITH SEEDS

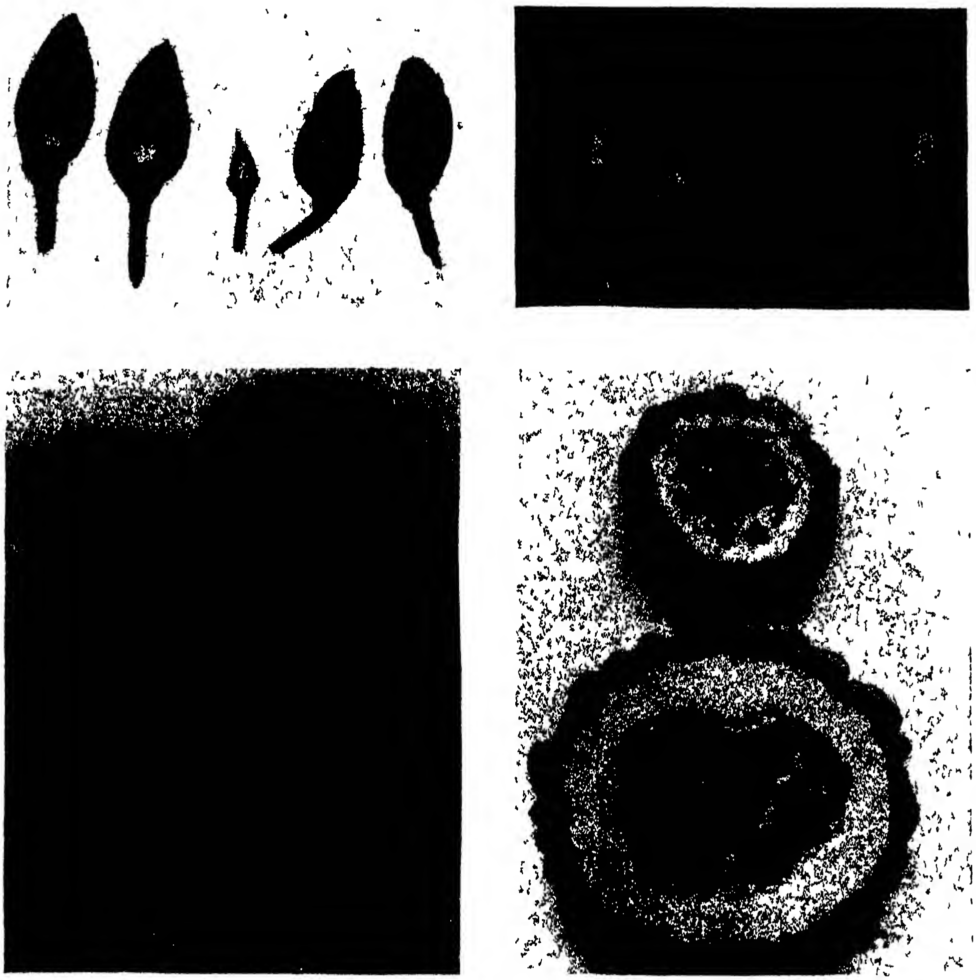


FIG 2 EFFECT OF ACID ON SEED DEVELOPMENT.

(*Top left*) THE MIDDLE FIGURE REPRESENTS THE ORIGINAL OVARY OF A TOBACCO FLOWER THE FRUITS ON THE LEFT WERE PRODUCED BY POLLINATION AND THE ONES ON THE RIGHT BY TREATING THE FLOWERS WITH THE POTASSIUM SALT OF INDOLE ACETIC ACID (*Top right*) THE FIGURE ON THE LEFT IS A CROSS SECTION OF THE FRUIT SHOWN ON THE LEFT IN THE ADJACENT PICTURE, WHILE THE ONE ON THE RIGHT WITHOUT SEEDS IS A CROSS SECTION OF THE FRUIT ON THE RIGHT IN THE SAME FIGURE (*Bottom left*) THE CROOKNECK SUMMER SQUASH WITH THE TAG WAS PRODUCED BY TREATING THE FLOWER WITH INDOLE BUTYRIC ACID, WHILE THE FRUIT ON THE RIGHT IS A NORMAL FRUIT (*Bottom right*) THE UPPER FIGURE WITHOUT SEEDS IS A CROSS SECTION OF THE PARTHENOCARPIC FRUIT WITH THE TAG IN THE ADJACENT PICTURE THE LOWER FIGURE IS A CROSS SECTION OF A NORMAL FRUIT WITH SEEDS

contain more growth hormone than the pistils from varieties that do not produce seedless fruits. Unlike the seeded fruits, the seedless fruits are produced without fertilization and in many cases even without pollination

Based on these findings, a hypothesis of fruit development has been formulated It has been suggested that normally the pollination and the development of the pollen tubes bring into the ovary a quantity of growth hormone which, together with that which is already present in the pistil, is sufficient to start the fruit growing. (Without pollination there will be no fruit development) The developing embryo in the seed may either produce more hormone or cause it to flow into the fruit from the leaves to supply the hormone needed for the continued growth of the fruit On the other hand, in some varieties of oranges and grapes the pistil contains enough hormone to initiate growth without pollination and fertilization, and here we have produced seedless fruits

These experiments, though scientifically interesting and important, have probably no commercial value It would be too expensive to treat each individual flower separately and that would as a rule be necessary. Attempts have been made to produce seedless dates with chemicals, but so far without any success If success were attained with this plant, it would be a commercial advantage

FELIX G. GUSTAFSON
UNIVERSITY OF MICHIGAN

INDUSTRIAL RESEARCH IN THE UNITED STATES

A GENERATION or two ago the word *science* became so highly respected that it was applied to all sorts of things, whether or not they had any relation to scientific work Even athletes, such as boxers, who had certain characteristics were said to be scientific More recently *research* has come to wear the purple In our universities it is rolled unctuously on the tongues of those who have seen it only from afar It is honored in industry, finance and government There is no other pillar of fire to guide us out of the night

For 30 years the center of gravity of scientific research has drifted from our universities toward our industries, and now the current is becoming strong toward governmental agencies All these trends arouse reflections At the moment, however, we may review the magnitude of industrial research

In 1938 there were 1,769 industrial research laboratories in the United States employing about 30,000 persons. The estimated annual expenditure of these laboratories is $100,000,000, with a wide margin of uncertainty The chemical industries employ more scientists and pay more for research than any other industries, the electric and communication industries coming second Together these two industries account for nearly half of industrial research.

Without any basis for comparison, the persons employed in industrial research and the expenditures for it appear enormous But only about one per cent of manufacturing corporations maintain research laboratories and only one sixth of one per cent of the value of their products is spent for research In a sense, research is a sort of insurance. Considered from that point of view, the expenditures for it seem extremely small. Enormously more is spent for fire and other insurance, enormously more is spent for insuring a continuing supply of raw materials Much more is spent for accounting and legal advice Much more is spent even in preparing for governmental agencies the numerous reports required of corporations

F R M.

INDEX

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